D. Assessment

1. Data

The data sources and dates are given in the acknowledgements section.

a. Distribution and stock structure

California scorpionfish is a generally benthic species found from central California to the Gulf of California between the intertidal and about 170 m (Eschmeyer et al., 1983; Love et al., 1987). A substantial, but unknown, portion of the stock resides in Mexican waters. It generally inhabits rocky reefs, but in certain areas and seasons it aggregates over sandy or muddy substrate (Frey, 1971; Love et al., 1987). Substantial numbers are found over soft substrate in the vicinity of Palos Verdes (Love et al. 1987). It is believed that its presence in this area is due to the large populations of ridgeback prawn (*Sicyonia ingentis*) that are linked to Whites Point sewer outfall (love et al. 1987). Catch rate analysis and tagging studies show that most, but not all, California scorpionfish migrate to deeper water to spawn during May-September (Love et al., 1987). Tagging studies on spawning aggregations over Dago Bank showed that individuals tend to return to the same spawning area (Love et al. 1987), but information is not available on non-spawning season site fidelity. Tags retuned from the non-spawning period ranged from El Segundo in the north to Long Beach in the south (Love et al. 1987). California scorpionfish are quite mobile and may not be permanently tied to a particular reef (Love et al. 1987). For example, several tagged California scorpionfish have been recorded to move from Santa Monica Bay to the Coronado Islands (Hartmann 1987).

Data from California Department of Fish and Game (CDFG) creel census showed lowest catch rates near Santa Barbara and generally increased to the south with greatest catches off Sand Diego around Catalina, San Clemente, and the Coronado Islands (Love et al. 1987). Catch rates were higher in 61-90 m and 121-150 m depth strata during the spawning season (May-September) and higher in 0-30 m and 31-60 m depth strata during the non-spawning season (October-April) (Love et al. 1987). However, not all fish migrate to deeper water at the same time during spawning season as mature and ripe individuals were also caught inshore (Love et al. 1987).

SCCWRP and Orange County Sanitation trawl data indicate large variations in population size (Love et al. 1987). Some of this variation may be due to El Niño events (Love et al. 1987). It is possible that the variation is due to movement of individuals rather than changes in population size because there is also an absence of other species from their normal areas at the same time (Love et al. 1987).

For stock assessment purposes the southern California population is assumed to be a single stock. This assumption is based on 1) similarities among CPUE indices and sanitation trawl surveys among sub-regions, 2) initial analyses using individual sub-stocks showed similar results among sub-stocks and the combined results were similar to a single stock analysis, and 3) paucity of data for some regions. The stock is truncated in the south at the international boarder. Catch from Mexican waters landed in Californian ports are excluded from the analysis.

b. Biological parameters

Age and growth

Love et al. (1987) used annuli on pterygiophore separately for each sex to estimate the parameters of the von Bertalanffy growth curve. The annuli were validated by observing seasonal development of the opaque zone on the sections' edges in fishes with 2-5 opaque zones. The von Bertalanffy parameters were estimated based on 182 females and 222 Males (Table D1.1). The parameters are in terms of total length.

$$L_t = L_\infty \left(1 - \exp\left[-k\left(t - t_0\right)\right]\right)$$

Table D1.1. Parameters of the von Bertalanffy growth curve for California scorpionfish off southern California estimated by Love et al. (1987).

Sex	L_∞	SE	k	SE	t_0	SE
Female	44.33	1.57	0.13	0.02	-1.90	0.42
Male	36.31	1.60	0.12	0.02	-3.86	0.68

No estimates of variation of length-at-age are available. The coefficient of variation of the length-at-age is assumed to be 0.05 for the assessment.

Length weight

Love et al. (1987) developed a length-weight relationship for California scorpionfish from 656 males and 371 females from southern California. They found a significant difference between males and females. The parameters are in terms of total length.

$W = aL^b$

where W is weight in grams, L is total length in centimeters.

a = 0.0196 and 0.0205, and b = 3.0102 and 3.0045 for females and males, respectively.

Conversion factors

California scorpionfish do not have a forked tail, therefore total length and fork length are equal. Love et al. (1987) provide conversion factors between standard length (SL) and total length (TL).

TL = 1.21SL + 1.02

SL = 0.82TL - 0.69

Maturity and fecundity

Few California scorpionfish are mature at age 1, but over 50% are mature at age 2 and most are mature at age 3 (Love at al. 1987). Gonad data collected from the bimonthly trawl survey conducted off Ventura and Santa Barbara from 1994 to 1995 (Steve Wertz, CDFG), shows a peak in May for females (Figure D1.1) indicating spawning occurs sometime between May and June. The proportion mature at length from the survey does not give a good indication of the size at maturity (Figure D1.2), but the GSI calculated as the gonad weight divided by the total weight suggests a linear function with length up to about 30 cm TL (Figure D1.3). For non-hydrated females assuming a maximum GSI of 0.02 at 30 cm TL, the GSI relationship with TL is

GSI = 0.0012TL - 0.0155

which can be used to generate a fecundity at size relationship

$$f_{TL} = \begin{cases} 0 & TL \leq 13 \\ (0.0012TL - 0.0155)W_{TL} & 13 < TL < 30 \\ 0.2W_{TL} & TL \geq 30 \end{cases}$$

where TL is the total length and W_{TL} is the weight at that total length. This relationship is developed from females sampled throughout the year and therefore does not represent total eggs, but should provide a reasonable relative measure of fecundity if the size of individuals that were sampled does not change during the year and that the relative differences in GSI among lengths is consistent throughout the year.

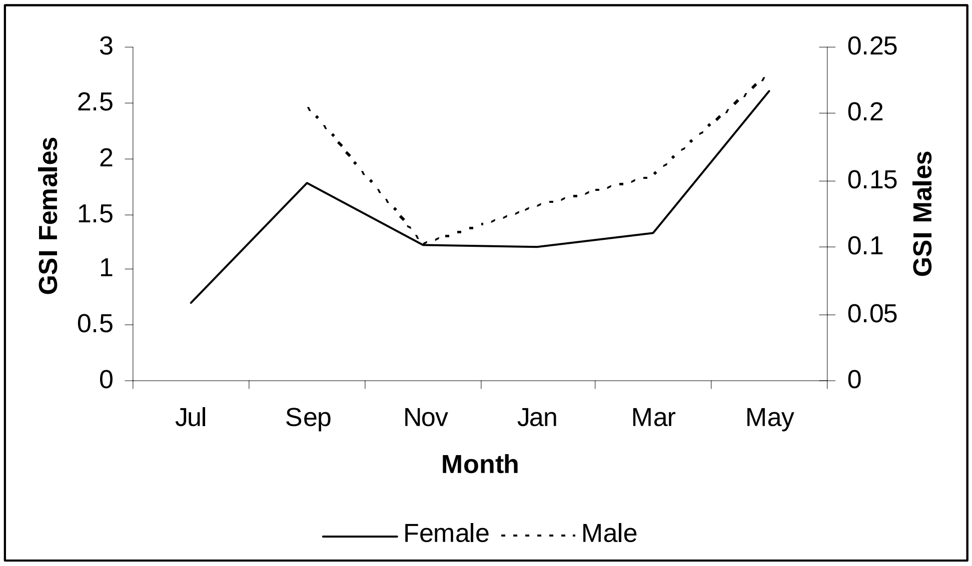


Figure D1.1. Seasonal Pattern in GSI index from the bimonthly trawl survey conducted off Ventura and Santa Barbara from 1994 to 1995 (Steve Wertz, CDFG).

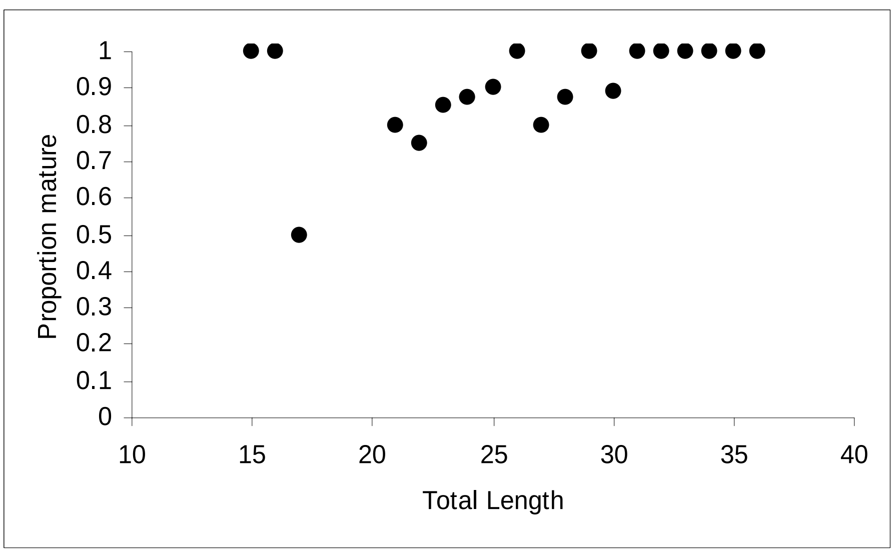


Figure D1.2. Proportion mature by length from the bimonthly trawl survey conducted off Ventura and Santa Barbara from 1994 to 1995 (Steve Wertz, CDFG).

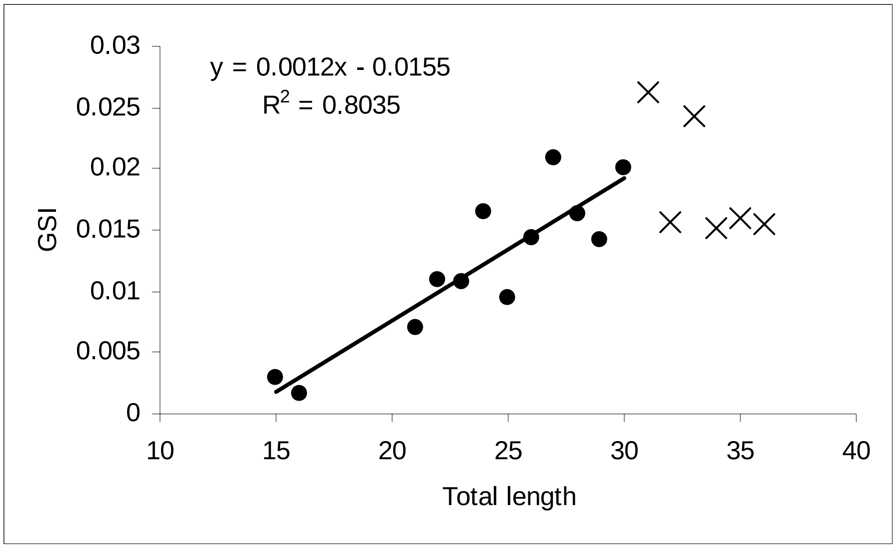


Figure D1.3. GSI (gonad weight/total weight) by total length for non-hydrated females assuming an asymptotic GSI at 0.02 at 30 cm TL using data from bimonthly trawl survey conducted off Ventura and Santa Barbara from 1994 to 1995 (Steve Wertz, CDFG). The data points marked with an X are not used in the regression.

Natural mortality

The maximum age observed by Love et al. (1987) was 21 and 15 years old for females and males, respectively. Approximately 20% of the fish were older than 11 years old (Table D1.2, Figure D1.4). Fish were sampled monthly from May 1981 to June 1982 and sporadically thereafter through May 1983. They used a 7.6 m or 4.9 m head rope otter trawl in 7-90 m of water, between Ventura and San Onofre. Thirty-four percent of the fish were not age-able due to malformed or poorly delineated annuli. The higher maximum age for females suggests that females have a lower total mortality rate than males. However, percent female decreases for the intermediate ages and then returns to about 50% for the older ages (Figure D1.5). The rapid decline in age-frequency and large age 12 plus group is inconsistent with standard catch-curve analysis.

Table D1.2. Frequency at age by sex from Love et al. (1987) Table 4. The numbers in the 12+ group represent all individuals aged 12 years and older and were calculated by subtracting the totals in Table 4 from Love et al. (1987) from the total number aged.

	count		Proportion of total		
age	Male	Female	Male	Female	Proportion female
2	7	3	0.03	0.02	0.30
3	31	31	0.14	0.17	0.50
4	62	43	0.28	0.24	0.41
5	40	31	0.18	0.17	0.44
6	15	24	0.07	0.13	0.62
7	4	11	0.02	0.06	0.73
8	9	3	0.04	0.02	0.25
9	5	1	0.02	0.01	0.17
10	7	2	0.03	0.01	0.22
11	4	1	0.02	0.01	0.20
12+	38	32	0.17	0.18	0.46
Total	222	182	1.00	1.00	0.45

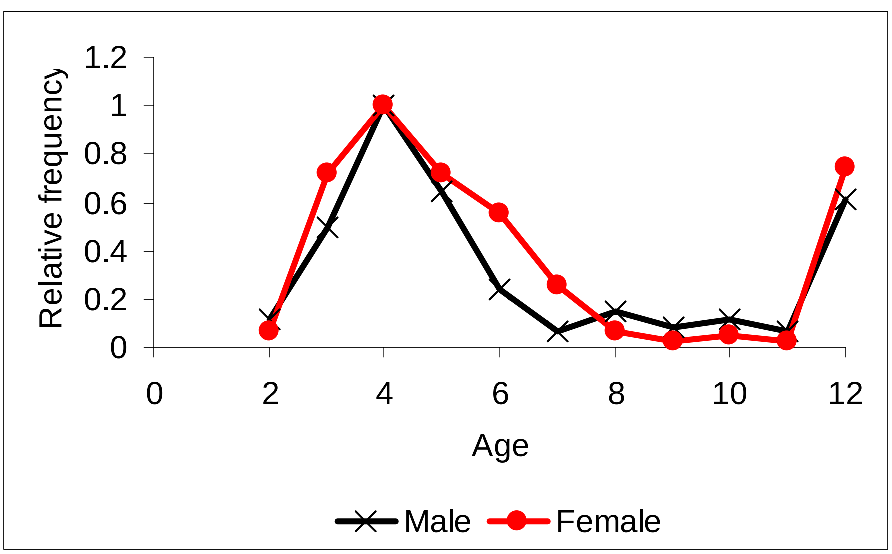


Figure D1.4. Relative age frequency by sex from Love et al. (1987). The data at age 12 is for all ages 12 and older.

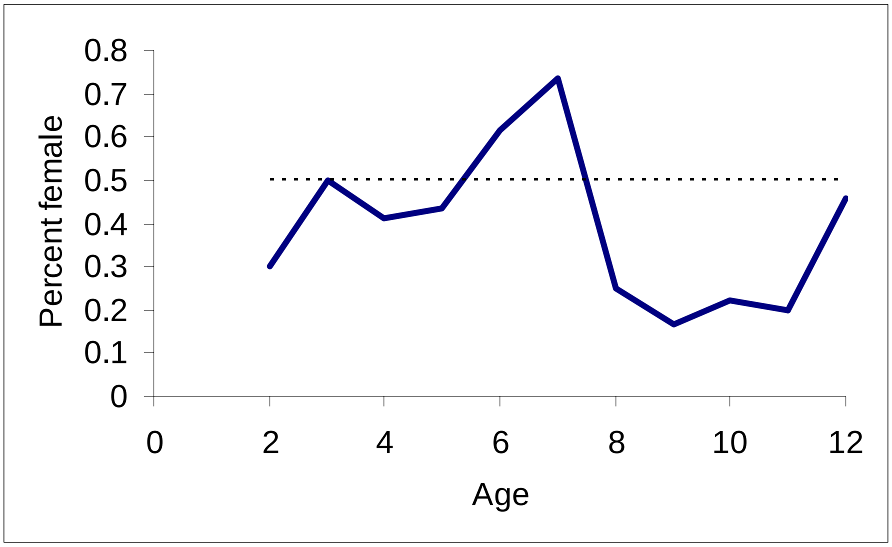


Figure D1.5. Proportion female from Love et al. (1987). The data at age 12 is for all ages 12 and older.

The age data collected by Love et al. (1987) contains about 20% of the individuals older than 11 years old. Females of this age would be greater than 35 cm TL. There are relatively few California scorpionfish caught greater than 35cm in the recreational, commercial, or sanitation surveys, except for the gillnet fishery. Therefore, the age data are inconsistent with the catch-at-length data unless the selectivity curves are dome shaped rather than asymptotic. In addition, the sex ratio from the age data shows a bias towards males for intermediate ages. A closer examination of the data shows that fish caught recreationally in the areas where the age data were collected tend to be larger than in other areas. This may indicate a bias in the sampling of the age data.

Due to unsuitability of catch-curve analyses and the violated assumptions of Hoenig's (1983) method, there is large uncertainty in the value of natural mortality for California scorpionfish. Cope et al. (2003) used a value of 0.25 for cabezon based on the maximum ages of 15 and 17 years for California and Washington, respectively. Cabezon is the most closely associated species with California scorpionfish in the recreational catch. A value of 0.25 was assumed for both sexes in the assessment.

Stock-recruitment relationship

There is no information about the stock-recruitment relationship for California scorpionfish. The species aggregates from multiple areas to spawn, uses "explosive" breeding assemblages, produces floating egg masses, and its larvae are found widely distributed off the coast of Baja California (Love et al. 1987, Moser 1993), indicating that recruitment is probably not locally driven and may be less related to stock size than for other species.

In a meta-analysis of stock-recruitment data for rockfish, Dorn (2002) estimated the mean steepness of the Beverton-Holt stock-recruitment relationship at approximately 0.65.

Steepness is the proportion of recruitment from an unexploited stock obtained when the population is at 20% of the unexploited stock size (Francis 1992). The estimate of mean steepness was lower when a Ricker stock recruitment model was used. These estimates were lower than those estimated by Myers et al. (2002) for the families Clupeidae (~0.7) and Gadidae (~0.8). Myers et al. (1999) provide estimates of steepness for three species in the family Scorpaenidae, which California scorpionfish is a member: chilipepper (*Sebastes goodei*), 0.35; Pacific ocean perch (*Sebastes alutus*) 0.43; and deepwater redfish (*Sebastes mentella*), 0.47. The estimate of steepness for the family was 0.48. Unfortunately, the data available for chilipepper is uninformative for steepness and Pacific Ocean perch covers many stocks much further north than the extent of California scorpionfish (Dorn 2002). The estimate of steepness for Pacific Ocean perch on the west coast of the United States from a highly informative data set is low, approximately 0.35 (Dorn 2002).

Unfortunately, information for steepness is not available for California scorpionfish and there is little information from related species that could be considered as a good proxy. A value of 0.7 was assumed for the assessment.

c. Landings

Scorpionfish are very hardy and have shown survival under extreme conditions. Therefore, for the purpose of this assessment, discard mortality is assumed to be negligible.

d. Historical catch

Recreational Landings

The recreational catch data comes from two sources, the RecFIN program and the Commercial Passenger Fishing Vessel (partyboat; CPFV) logbooks. RecFIN data are based on the Marine Recreational Fisheries Statistics Survey (MRFSS) catch estimates. The MRFSS was conducted from mid-1979 through 2003, with a hiatus from 1990 through 1992. MRFSS consists of an angler field survey paired with a randomized telephone survey. Total catch and effort are estimated for the whole southern California region in the MRFSS database, and the catch from smaller sub-areas is not provided. Since 1936, CPFV operators have been required to submit logbooks to CDFG for each fishing trip. Information is provided on the number of anglers, the number of hours fished, location of catch, and the type and quantity of fish caught. CPFV logbook data by trip is available since 1980; earlier data are only available in summarized form. Comparison of catch estimated by MRFSS for the CPFVs does not correspond well with the catch reported by the CPFV logbooks (Figure D1.6). The catches are similar in several years, but MRFSS estimates some substantial spikes in catch 1982, 1989, and 1996. These years have catch that is two to four times higher than for other years and for that reported in the logbooks. This variation is outside the 95% confidence intervals. Comparisons of the different modes of fishing from the MRFSS survey shows that CFPV (57%) and private/rental boats (42%) comprise most of the recreational catch (Figure D1.7).

However, the estimated proportion varies substantially from year to year. There does not appear to be any trend in the proportion taken by the two main modes (D1.8). There was no fishing during World War II. The LA Times data (http://swfscdata.nmfs.noaa.gov/LaTimes/) provides a poor representation of the catch for years before 1987, but has higher catch compared to the logbook data in the late 1980s early 1990s (Figure D1.9).

Catch for the stock assessment

The recreational catch for the assessment is calculated under the assumption that the CPFV logbook data are the most reliable estimate of annual recreational catches. It is assumed that approximately 80% of the CPFV trips were recorded on logbooks submitted to CDFG. For 1936 to 2004 the CPFV logbook catch data are first increased to account for the reporting level. The catch data are then expanded to include all modes of fishing based on the fraction of the total RecFIN catch taken by the CPFV fleet (0.5767). The catch in 1935 is assumed equal to the average of the catch for the 5 years before Would War II interrupted the fishery (1936-1940) and a linear trend is assumed to a catch of zero in 1916. The catch is given in Figure D1.10.

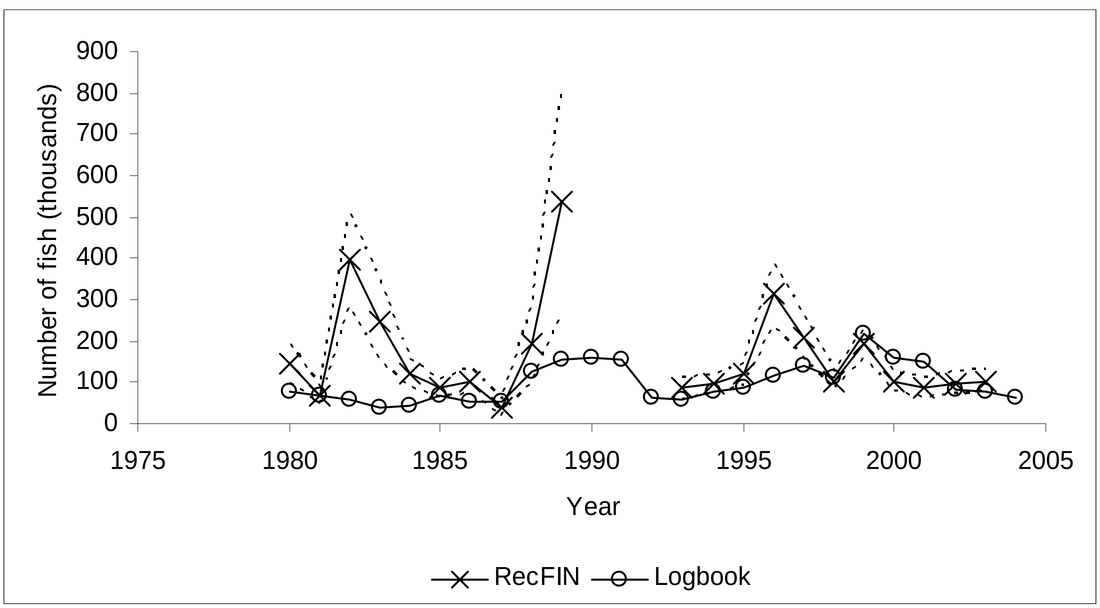


Figure D1.6. Comparison of catch estimated by MRFSS for the CPFVs with the catch reported on the CPFV logbooks. The dashed lines are the 95% confidence intervals for the MRFSS estimates

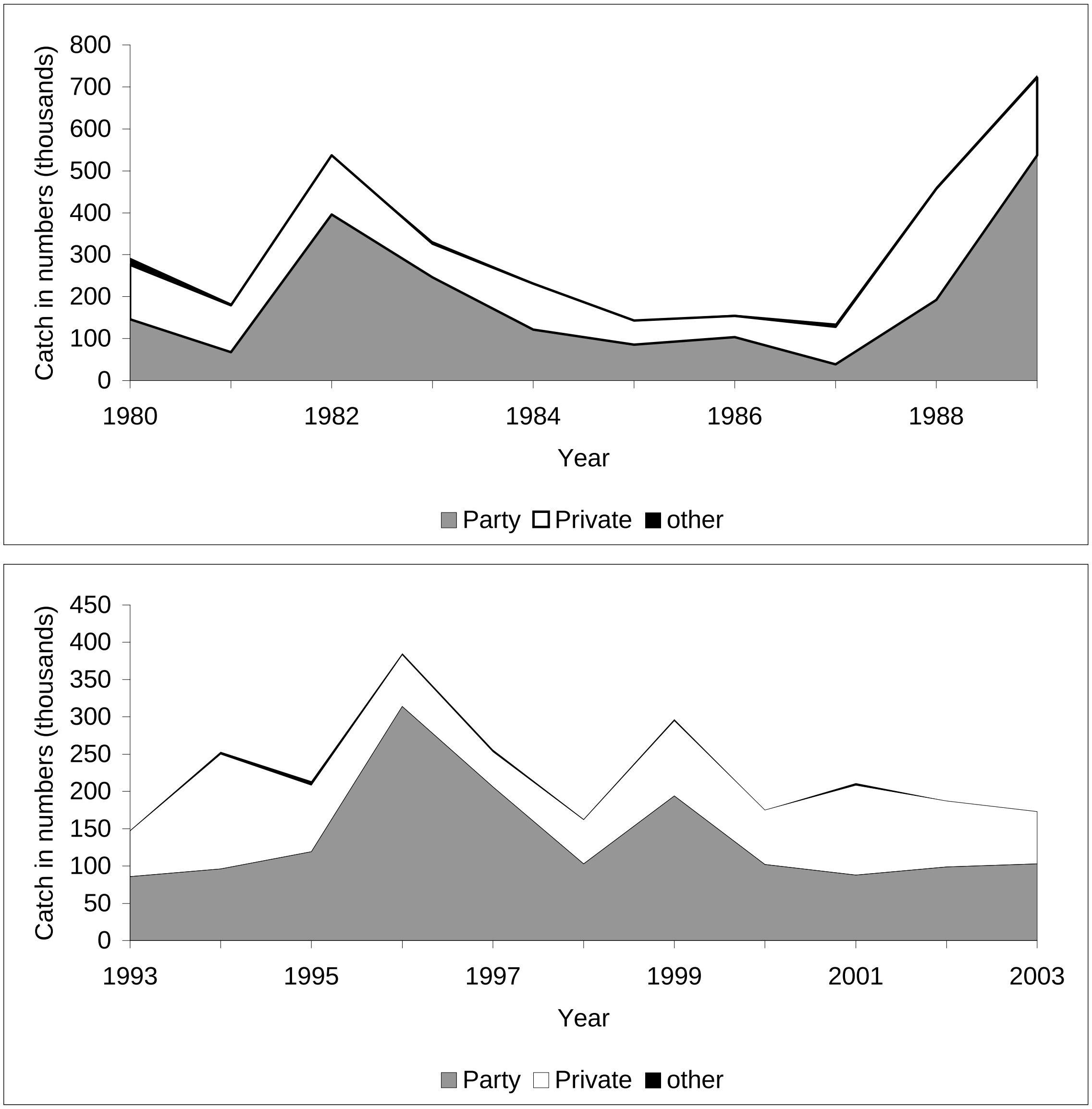


Figure D1.7. Recreational catch by modes of fishing from MRFSS

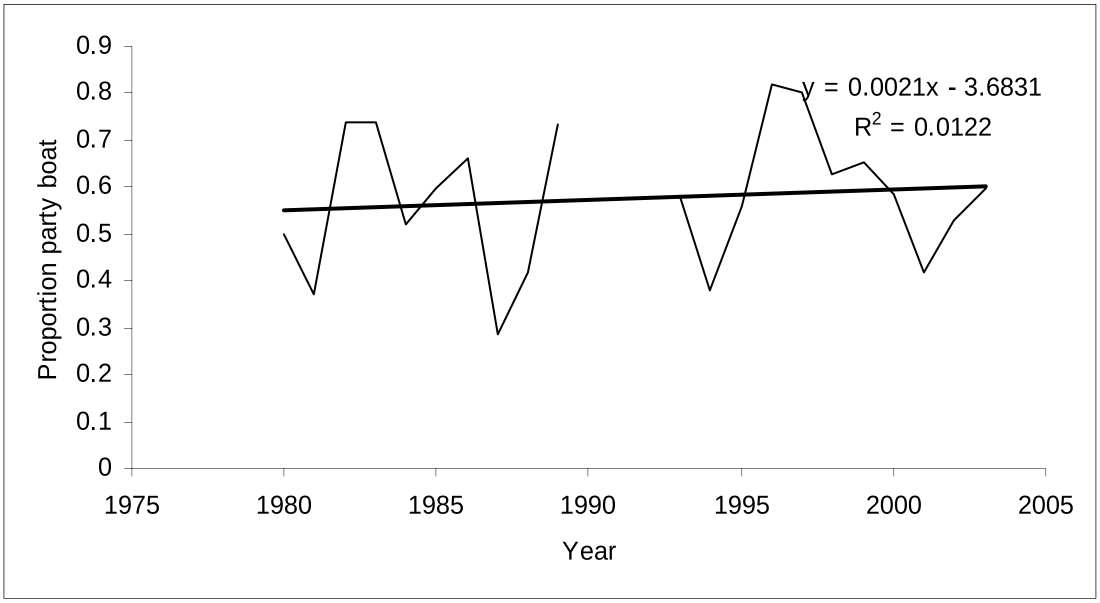


Figure D1.8. Proportion of the recreational catch taken by party boats calculated from MRFSS data.

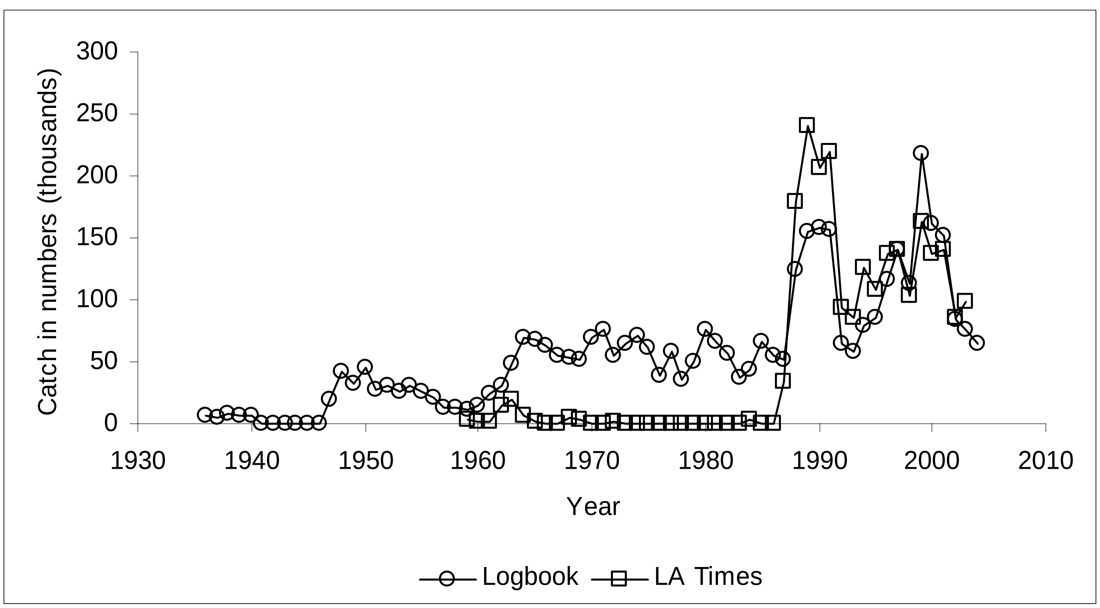
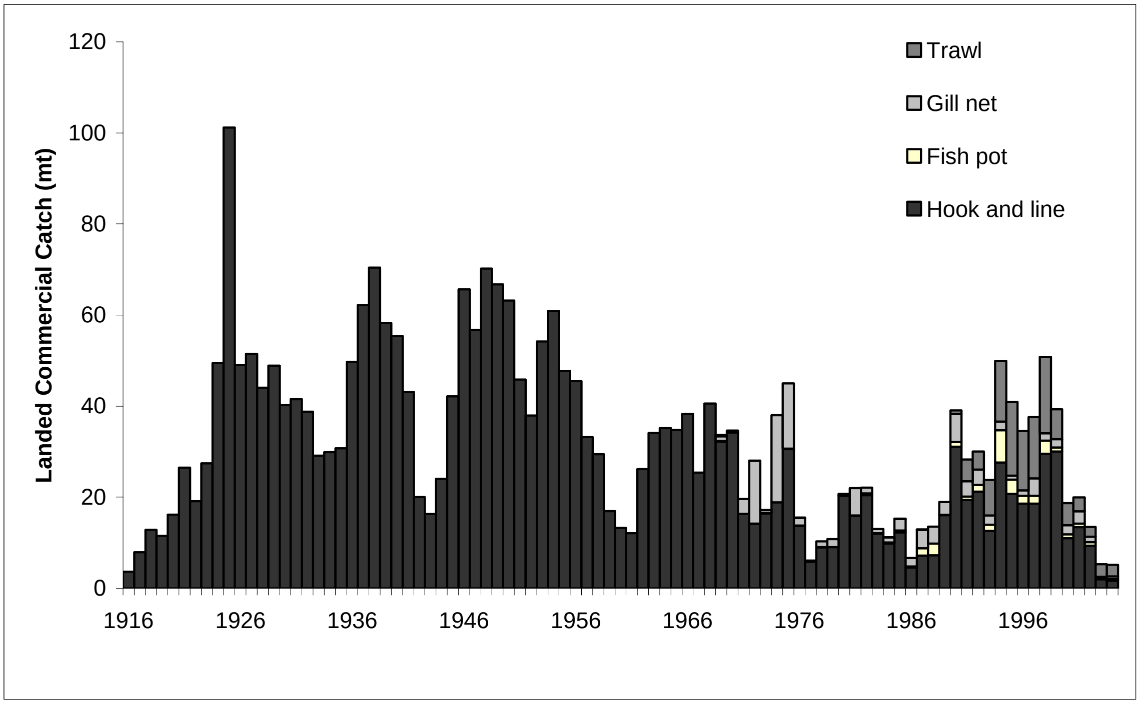


Figure D1.9. Comparison of catch from all ports from the logbook program and the LA Times data.



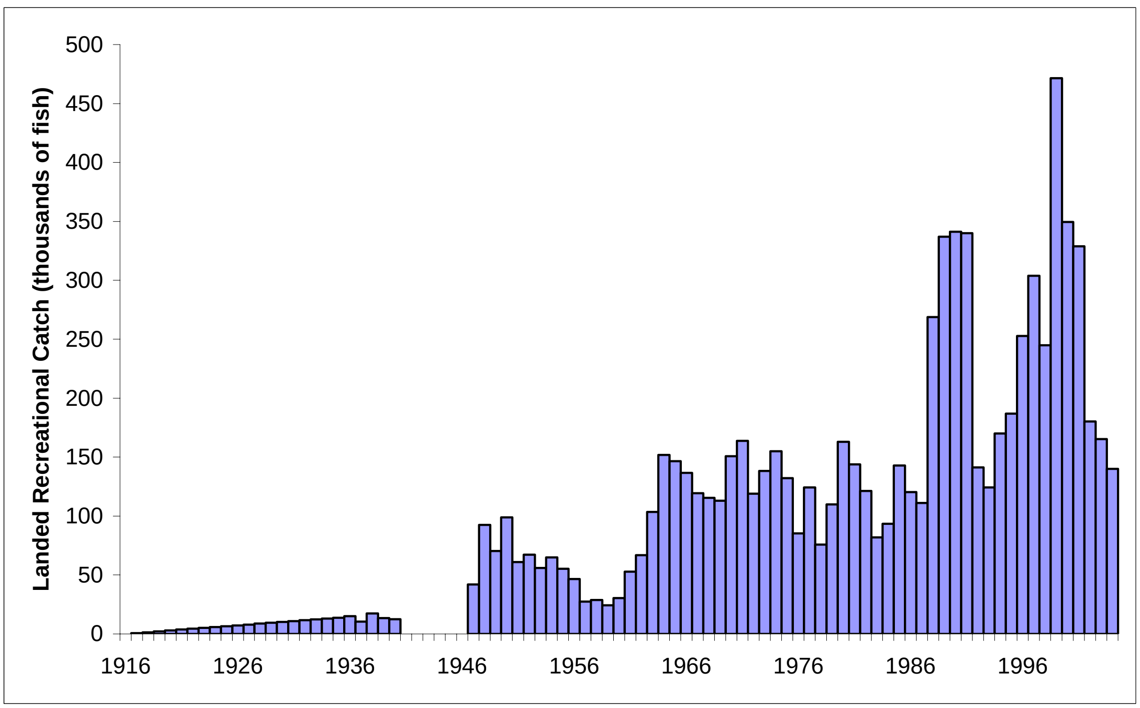


Figure D1.10. Catch used in the assessment.

Commercial Landings

There are several sources of commercial catch data available for California scorpionfish (often reported as "sculpin" in historical landing records). The earliest data starts in 1916 and data are available up to 2004. The data sets differ substantially in some years.

CalCom

The California Commercial Cooperative Groundfish Program (CalCom) landings database contains, among other information, catch in pounds by gear and port for 1978 to 2004.

CFIS

The Commercial Fisheries Information System (CFIS) also has catch in pounds by gear and port for 1969 to 2004 (Figures D1.11, D1.12). It also separates the data from that caught in California waters and that caught in Mexican waters. These data come from landing receipts or "fish tickets" filled out by the markets or fish buyers as required by the state for all commercial landings.

PFEL

The Pacific Fisheries Environmental Laboratory (PFEL) data (http://las.pfeg.noaa.gov:8080/las_fish1/servlets/dataset) includes California commercial landings data digitized from original tables published by the CDFG (D1.13). These data come from receipts or "fish-tickets" filled out by the markets and packing facilities as required by the state for all commercial landings. The landings for 1928 to 1976 were published by CDFG in their Fish Bulletin series. Landings from 1977 to 1980 were obtained from the CDFG Statistical Division and landings from 1981 to 2002 were obtained from Pacific Fisheries Information Network (PacFIN). The data only includes catches taken in California waters. A substantial amount of California scorpionfish landed in California were from Mexican waters and these are not included in the PFEL data set. We extracted data from PFEL using the scorpionfish market category.

California Explores the Ocean

California Explores the Ocean (CEO) provides several types of data taken from the CDFG Fish Bulletins in electronic form. One data set includes yearly landings in pounds for 1916 to 1947. Two other data sets include catch by area and month from 1926 to 1935 and from 1931 to 1976. Another data set provides the amount of catch caught north and south of the state borders from 1940 to 1976. (http://ceo.ucsd.edu/fishcatchtables/fish-catch-download.html)

CDFG Fish Bulletin

Landings from 1916 to 1935 are presented in CDFG Fish Bulletin No. 49 and bulletin No. 149 provides tabulated data from 1916 to 1968. Data by area and month are given in a series of bulletins, each bulletin usually providing information for a single year. Data by area and month is available for 1926 to 1986. The bulletins also provide information of the amount of catch landed in California caught north and south of the state boundaries. Electronic copies of the bulletin can be found at (http://ceo.ucsd.edu/fishbull/).

Comparison of Data Sets

The data sets generally rely on the CDFG Fish Bulletins for their data or similar sources used to generate the bulletins. However, the PFEL data set does not include data for fish caught outside the state boundaries and therefore differs substantially from the other data sets for the mid 1960s to the mid 1980s. The CEO data set duplicates the data from the bulletins for the data set that includes yearly landings in pounds for 1916 to 1947. However, the CEO data sets that include catch by area and month differ from the bulletins, particularly the data set for 1931 to 1976. The CEO data that gives the origin of the catch south of the state border for 1940 to 1976 are equal to the difference between the PFEL data and the bulletin data. For 1953 to 1960, the catch within the state is not equal to the PFEL data. The CalCOM data are within a few percent of the bulletin data. The CFIS data set is within a few percent of the CalCOM data except for the years 1992 and 1997 where the differences are larger. The CalCOM and CFIS data sets have catch by gear, the other data sources do not. All the data sets have catch by month, but this is not used in the analysis.

Data Sets Used in the Analysis

The assessment is of the southern California population of scorpionfish. In most years 99% or more of the landings occur in the southern California ports. Therefore, only landings in the Santa Barbara, Los Angeles, and San Diego areas are included. We also exclude catch taken in Mexican waters, but landed in California ports.

Data by gear (from CFIS) are only available starting in 1969. All catch before 1969 is assumed to be taken by hook and line. It is assumed that before 1928 there was no catch taken from Mexican waters landed in California. The catch is divided into four gear types: hook and line, fish pot, trawl, and gill net. Catch taken by other gears is added to the hook and line catch. Catch by gear for 1969 to 2004 is taken from CFIS. Catch for 1928 to 1968 is taken from PFEL. Catch for 1926 and 1927 is taken from the CDFG Fish Bulletins. Catch for 1916 to 1925 is taken from the CDFG Fish Bulletins. Commercial catch used in the assessment is given in Figure D1.10.

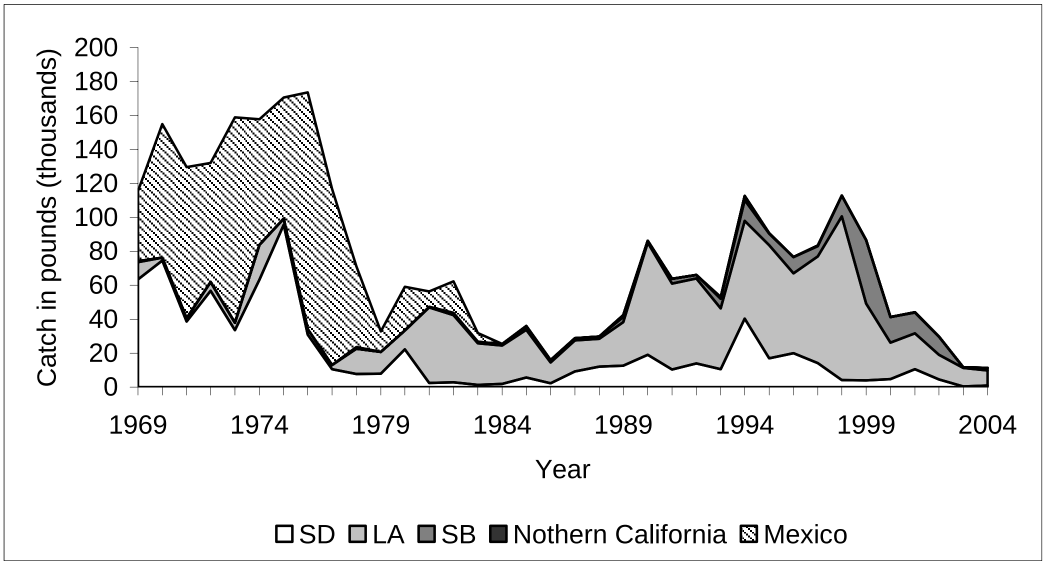


Figure D1.11. Commercial catch by region from the CFIS database.

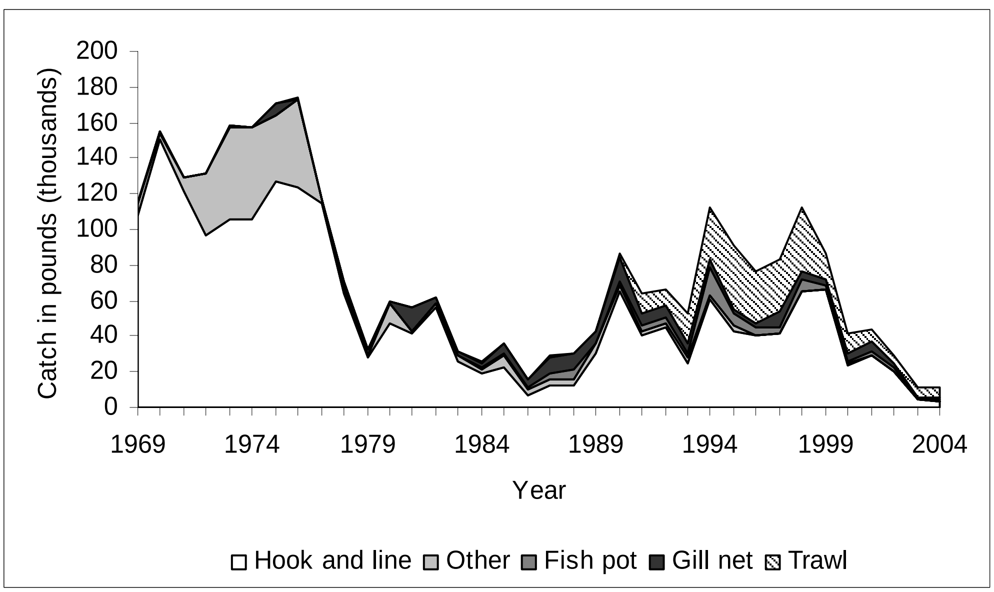


Figure D1.12. Commercial catch by fishing method from the CFIS database.

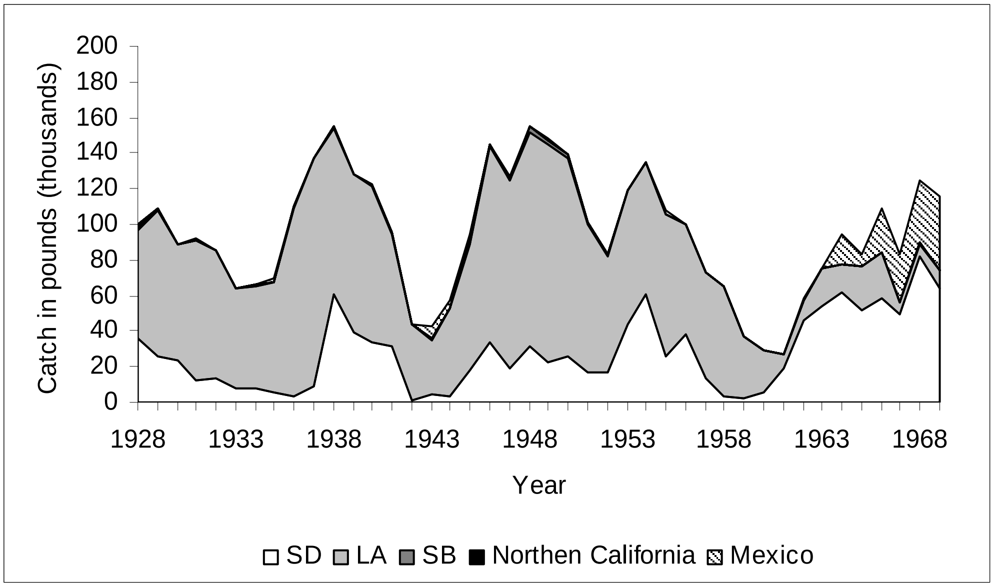


Figure D1.13. Commercial catch by region from the PFEL database.

e. Age and length compositions

<u>RecFIN Length Frequency Data</u>.
Size of fish (total length) in the recreational fishery is available from the RecFIN program (Table D1.4). Figure D1.14 shows the relative frequency of fish in 1 centimeter categories converted from total/fork length to standard length. The data represents measurements taken at interviews when the fish were landed, during the years 1980-2003 and includes all modes of recreational fishing.

Table D1.4. Sample sizes for length-frequency data.

Year	RecFIN	Observer	Trawl	Hook and line	Gillnet	Sanitation
1972						32
1973						29
1974						28
1975		935				21
1976		941				36
1977		1373				57
1978		1729				25
1979						262
1980	415					271
1981	387					324
1982	507					502
1983	422					106
1984	435					47
1985	365					83
1986	362	650				144
1987	133	1145				177
1988	652	2872				141
1989	653	3262				124
						203
						182
						183
1993	362					306
1994	362					322
1995	323					351
1996	808		237	25	27	463
1997	468		758	85	310	444
1998	802		352	197	13	358
1999	2444		591	202	21	456
2000	1048		110	24	11	476
2001	590		224	139	194	537
2002	1022		0	71	59	1573
2003	1207		70	6	51	409
2004			22	0	33	720

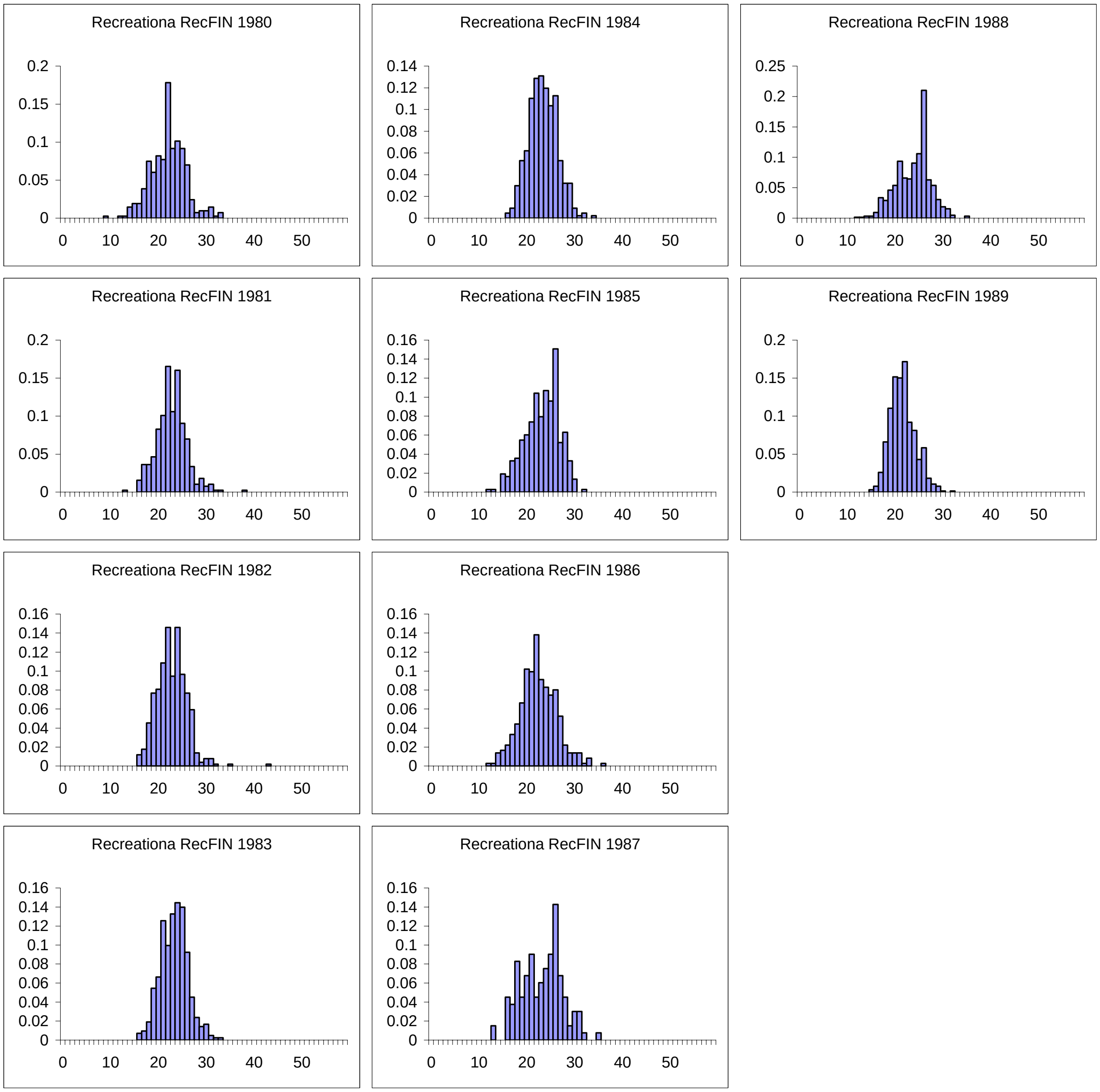


Figure D1.14. Length frequency distribution by year in standard length (cm) from the RecFIN database.

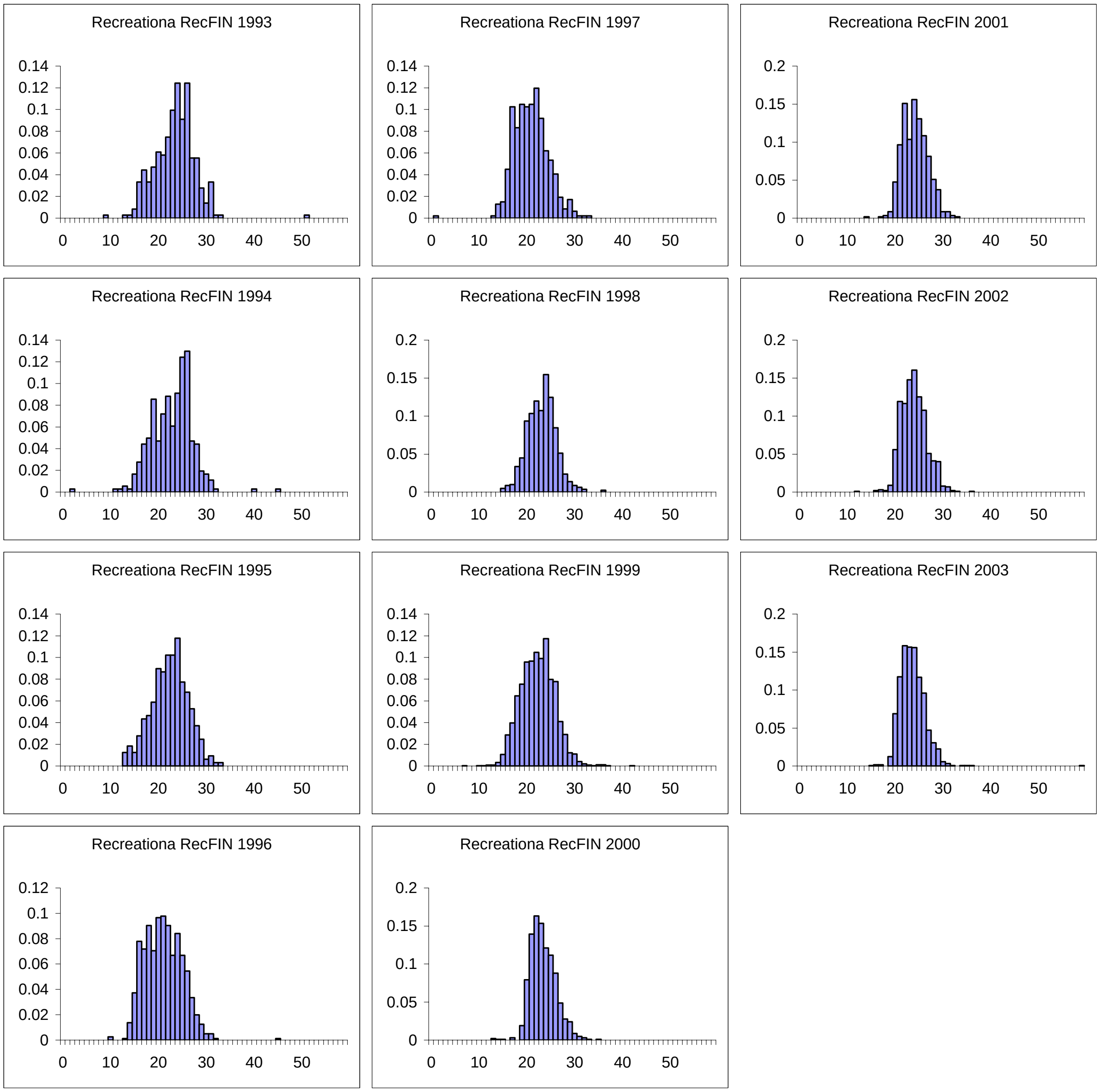


Figure D1.14 continued. Length frequency distribution by year in standard length (cm) from the RecFIN database.

CPFV Length Data

<u>CPFV Observer Programs</u>

The data were obtained from two CDFG partyboat observer programs, one in the late 1970s and another in the late 1980s, and represent measurements of total length taken on board the vessels by the observer (Table D1.4). Figure D1.15 shows the relative frequency of fish in 1 centimeter categories converted from total/fork length to standard length.

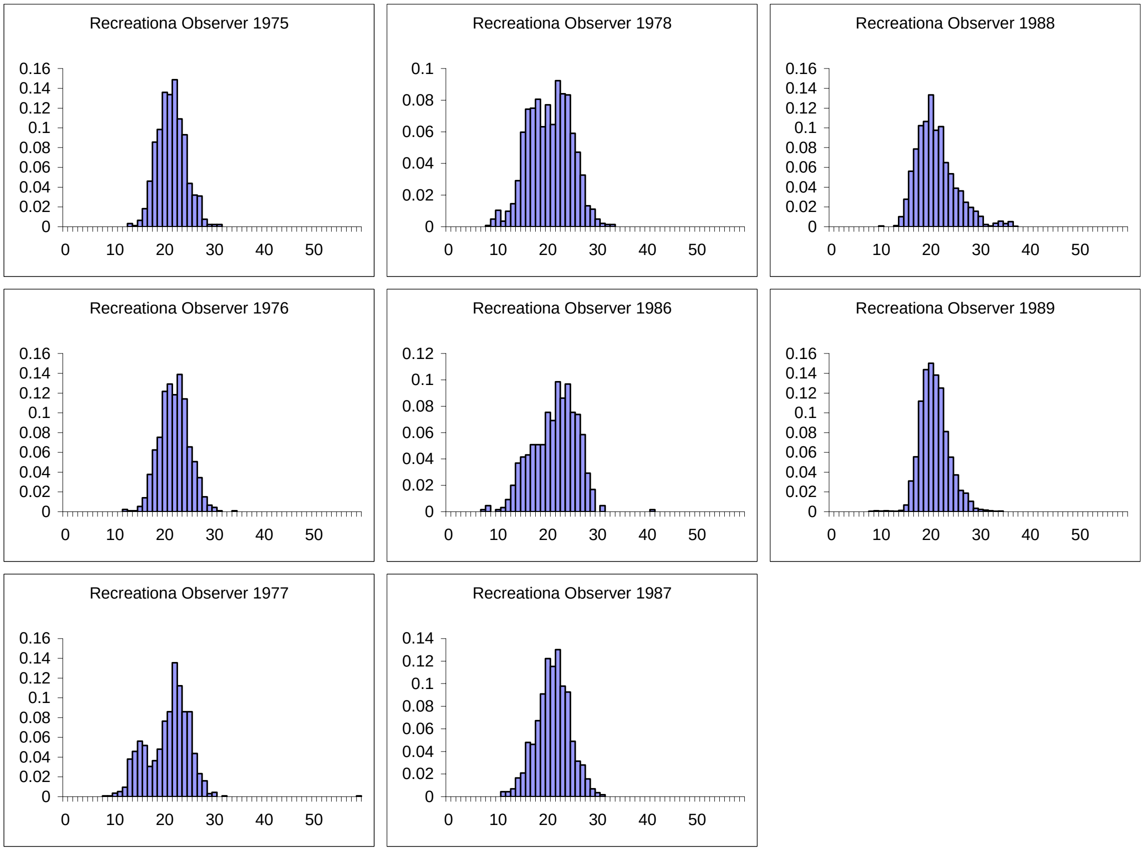


Figure D1.15. Length frequency distribution from the observer data by year in standard length (cm).

Commercial Length Data

<u>Commercial Length Frequency Data</u>
Commercial length data are available form CalCOM, PacFIN, and the CDFG sampling program. Only 79 fish were available from the PacFIN database and they were all from 1999. These contained 60 trawl caught length measurements from Ventura County and 19 hook and line caught length measurements from Santa Barbara County. Few fish were available from the CalCOM data base and all for 1999 and for the Santa Barbara County (some data for Los Angeles had borrowed length-frequencies from Santa Barbara). The CalCOM data contained both hook and line and trawl length frequencies, but the lengths were much greater than from PacFIN. More years of data are available from the CDFG sampling program (Table D1.4) and it appears that the PacFIN data are included.

Figure D1.16 shows the relative frequency of fish in 1 centimeter categories by gear converted from total/fork length to standard length. The data were obtained from the CDFG port sampling program data base and represent measurements taken when the fish were landed.

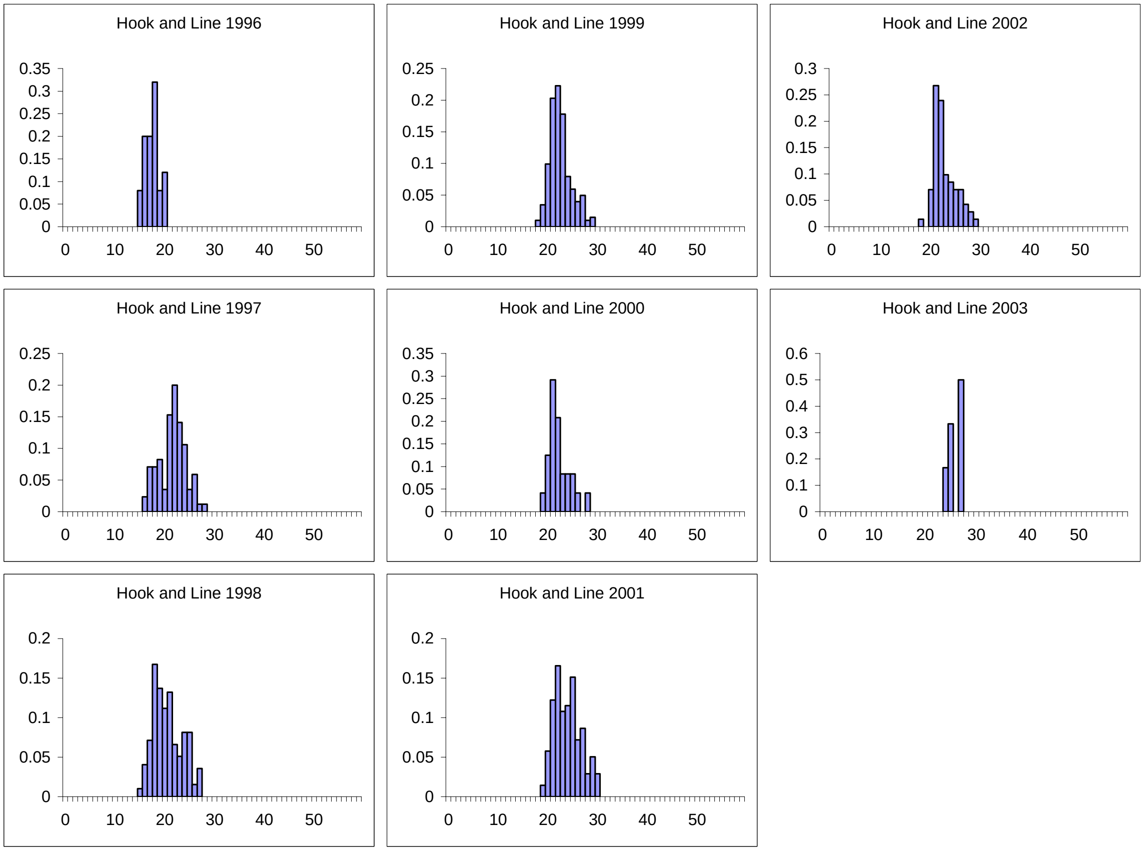


Figure D1.16a. Length frequency distribution from the hook and line commercial fisheries by year in standard length (cm).

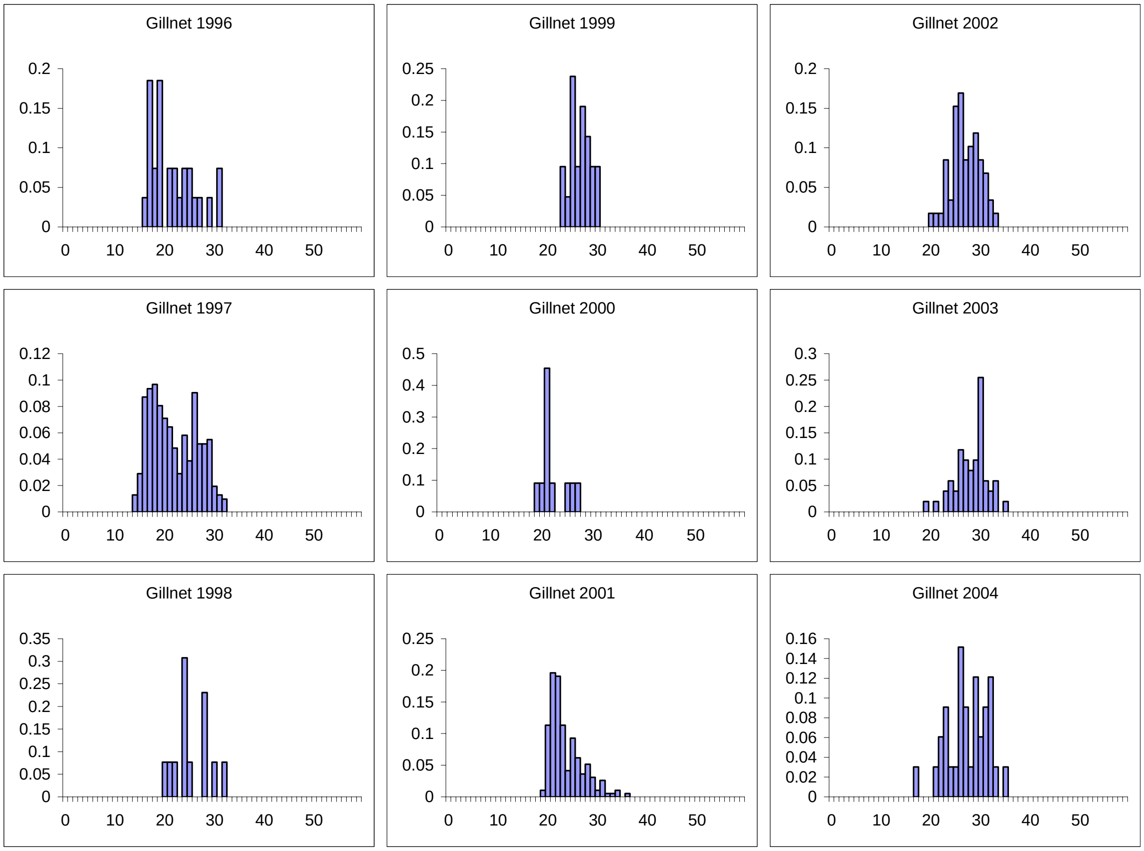


Figure D1.16b. Length frequency distribution from the gillnet commercial fisheries by year in standard length (cm).

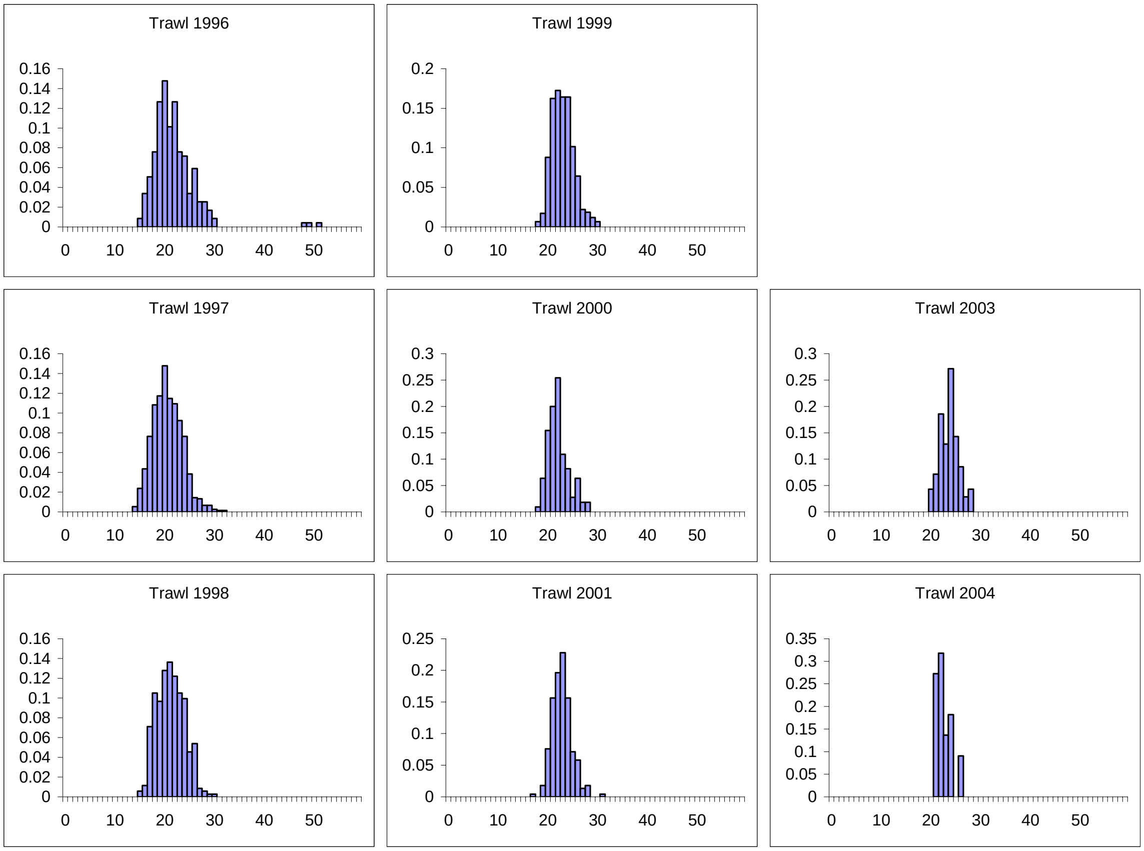


Figure D1.16c. Length frequency distribution from the trawl commercial fisheries by year in standard length (cm).

f. Indices of abundance

<u>CPFV Trip Data</u>

Trip level catch and effort data are available from the CPFV logbook data from 1980 to 2003. The analysis was conducted for 8 areas and restricted to CDFG blocks that were considered important California scorpionfish areas (Table D1.5, Figure D1.17). Of the 236 CFG blocks south of Pt. Conception, we considered only the CFG blocks with cumulative historical removals of 10,000 or more scorpionfish between 1980 and 2004. These 36 blocks accounted for 93% of the total California catch reported in the logbooks. These blocks were then grouped into eight relatively homogeneous geographic areas for purposes of calculating GLMs. A delta-gamma model is used to regress catch in numbers per angler hour versus the explanatory variables year, month and CDFG block. A binomial model is used to model the proportion positive and a gamma model is used to model the distribution of positive observations. The same explanatory variables are used in both the binomial and gamma components of the model. A combined year effect from the binomial and gamma models is used to represent the relative abundance (Table D1.6). A jackknife procedure is used to calculate standard errors for the year effects. The regression was run separately for each of the sub-areas. The analysis was carried out using the R code provided by E.J. Dick. Based on the AIC criteria, all the explanatory variables were included in the analyses for all sub-areas.

A combined index for the southern California stock was created by summing the indices for all areas, excluding the Mexican area, weighted by the number of blocks used in each area.

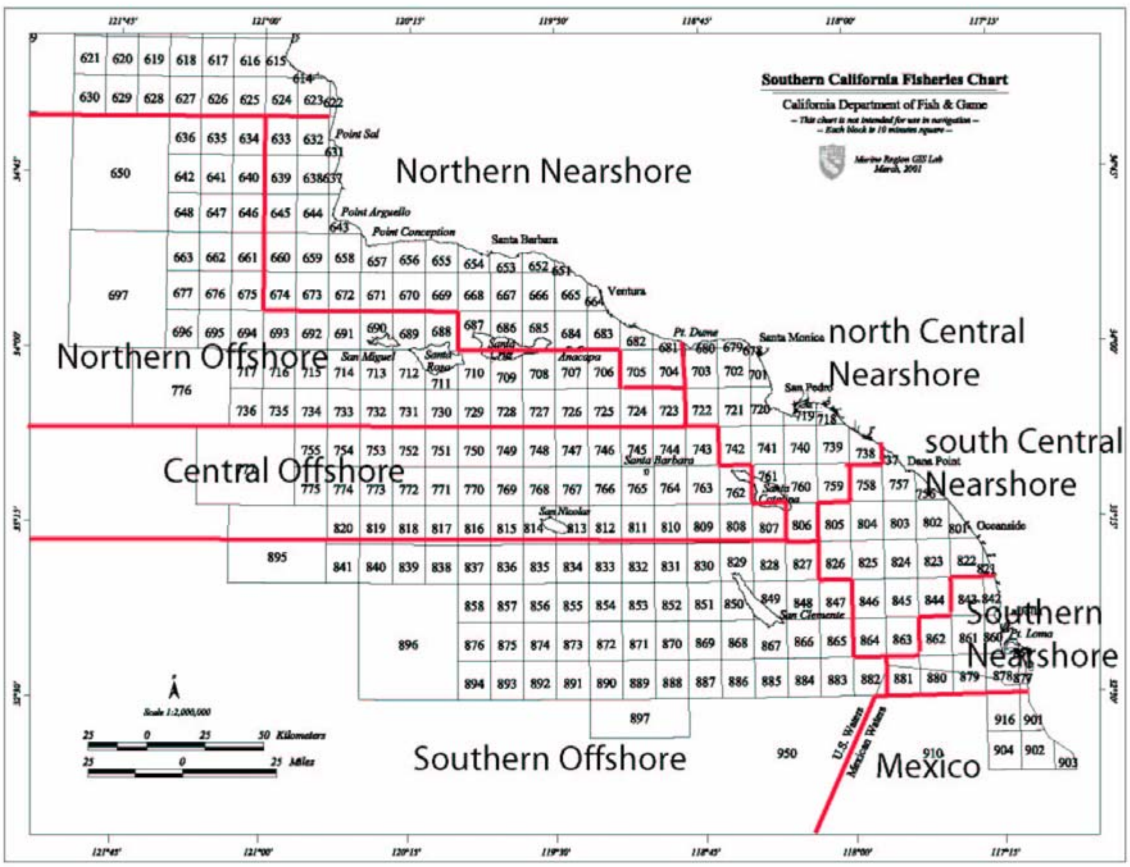


Figure D1.17. Definitions of sub-areas used in the CPUE analysis.

Table D1.5. Blocks used in the CPFV CPUE analysis (see Figure D1.17 for area definitions).

NN	NO	nCN	CO	sCN	SN	SO	MEX
652	689	678	762	737	842	829	901
653	690	679	765	756	843	849	902
665	706	680	807	757	860	850	916
666	707	701	808	801	861	867	
667	708	702	813	802	864	897	
681	709	703	814	803	877		
682	711	718		821	878		
683	729	719		822	879		
684	730	720		823			
685	734	721					
686		738					
687		739					
		740					
		741					
		742					
		759					
		760					
		761					
		806					

Table D1.6. Index and coefficient of variation for the trip level CPFV delta-gamma CPUE standardization.

	NoNear		NoOff		NoCenNear		CenOff		SoCenNear	
year	Index	cv	Index	cv	Index	cv	Index	cv	Index	cv
1980	0.0072	0.22	0.0139	0.75	0.0773	0.18	0.0121	0.2	0.028	0.24
1981	0.0059	0.15	0.0167	0.63	0.0596	0.15	0.0144	0.19	0.0176	0.13
1982	0.0074	0.15	0.0378	0.76	0.049	0.13	0.0347	0.5	0.0184	0.19
1983	0.0115	0.45	0.0068	0.48	0.0326	0.12	0.018	0.19	0.011	0.12
1984	0.0052	0.24	0.0017	0.33	0.0427	0.14	0.0497	0.43	0.0154	0.15
1985	0.0077	0.25	0.0075	0.49	0.0789	0.21	0.0224	0.27	0.032	0.21
1986	0.0136	0.22	0.0041	0.45	0.0677	0.14	0.0514	0.58	0.0222	0.12
1987	0.0114	0.16	0.0109	0.4	0.0598	0.2	0.0129	0.22	0.0401	0.43
1988	0.0176	0.1	0.0189	0.24	0.1168	0.11	0.0189	0.2	0.0544	0.11
1989	0.0247	0.27	0.0316	0.23	0.1737	0.11	0.0361	0.18	0.0408	0.17
1990	0.0206	0.15	0.0252	0.2	0.1104	0.1	0.042	0.27	0.0628	0.16
1991	0.0181	0.13	0.0438	0.41	0.1394	0.12	0.0578	0.16	0.0809	0.16
1992	0.0141	0.16	0.0311	0.24	0.0464	0.12	0.0334	0.18	0.0423	0.18
1993	0.0176	0.14	0.0263	0.25	0.0618	0.12	0.0435	0.22	0.0257	0.15
1994	0.0257	0.24	0.049	0.36	0.0788	0.09	0.0477	0.17	0.0543	0.2
1995	0.0218	0.18	0.0349	0.31	0.0874	0.13	0.0312	0.2	0.0656	0.16
1996	0.0316	0.17	0.0263	0.24	0.1126	0.11	0.0296	0.15	0.0755	0.15
1997	0.0268	0.09	0.0239	0.15	0.0739	0.1	0.0235	0.18	0.0611	0.15
1998	0.0296	0.13	0.0365	0.16	0.0913	0.14	0.0252	0.15	0.0379	0.15
1999	0.0345	0.14	0.0257	0.18	0.2058	0.13	0.0373	0.2	0.0612	0.17
2000	0.0356	0.39	0.0135	0.28	0.156	0.12	0.024	0.18	0.0691	0.21
2001	0.027	0.12	0.0385	0.27	0.1326	0.11	0.0398	0.26	0.0629	0.12
2002	0.0132	0.22	0.0294	0.34	0.069	0.18	0.0094	0.33	0.0373	0.18
2003	0.0075	0.27	0.0105	0.42	0.0631	0.2	0.0022	0.46	0.0315	0.27

SoNear		SoOff		Mex		Total	
Index	cv	Index	cv	Index	cv	Index	cv
0.0205	0.2	0.0404	0.22	0.0616	0.31	2.38	0.12
0.0198	0.12	0.0429	0.19	0.0271	0.33	1.99	0.10
0.0243	0.12	0.0502	0.14	0.04	0.37	2.22	0.15
0.0151	0.18	0.0344	0.14	0.0321	0.32	1.33	0.08
0.0162	0.15	0.0377	0.21	0.0198	0.46	1.65	0.11
0.0435	0.23	0.0355	0.16	0.0171	0.33	2.61	0.13
0.0292	0.1	0.029	0.36	0.071	0.37	2.38	0.11
0.0218	0.12	0.0424	0.22	0.0253	0.34	2.21	0.13
0.0329	0.16	0.0459	0.24	0.0203	0.27	3.72	0.07
0.0414	0.19	0.0317	0.21	0.0701	0.31	4.99	0.08
0.0556	0.12	0.0418	0.17	0.0638	0.36	4.07	0.06
0.1025	0.28	0.0522	0.15	0.1013	0.31	5.46	0.08
0.0276	0.1	0.0326	0.2	0.0574	0.36	2.33	0.07
0.0278	0.14	0.0381	0.13	0.0707	0.36	2.55	0.07
0.026	0.15	0.0383	0.29	0.0913	0.33	3.47	0.08
0.0398	0.14	0.0292	0.3	0.0363	0.6	3.51	0.08
0.0387	0.13	0.0169	0.19	0.0443	0.27	4.03	0.07

0.0679	0.24	0.0148	0.31	0.0414	0.3	3.27	0.07
0.0404	0.15	0.0095	0.23	0.041	0.36	3.32	0.08
0.0779	0.15	0.0109	0.27	0.053	0.29	6.03	0.09
0.0955	0.13	0.009	0.19	0.0319	0.33	5.10	0.08
0.1043	0.15	0.0221	0.2	0.0867	0.23	4.98	0.07
0.0466	0.22	0.0073	0.18	0.0571	0.29	2.57	0.11
0.0274	0.3	0.0058	0.29	0.0679	0.24	1.94	0.14

CPFV month and block summarized data

Month and CDFG block summarized catch and effort data are available from the CPFV logbook data from 1936 to 2004, with a hiatus from 1941 to 1946 due to WWII. Month information is not available for 1979 so this year is left out of the analysis. Data for 2004 is only preliminary. Only data from the same CDFG blocks identified in the analysis of the trip CPUE data as important California scorpionfish areas are used in the analysis. The data from 1980 to 2003 include catch and effort data that were also contained in the trip level CPUE analysis. A delta-gamma model is used to regress catch in numbers per angler hour versus the explanatory variables year, month and CDFG block. A binomial model is used to model the proportion positive and a gamma model is used to model the distribution of positive observations. The same explanatory variables are used in both the binomial and gamma components of the model. A combined year effect from the binomial and gamma models is used to represent the relative abundance (Table D1.7). The regression was run separately for each of the sub-areas. The analysis was carried out using the R code provided by E.J. Dick. The data were obtained from Dr Kevin Hill, NMFS SWFSC. Based on the AIC criteria, all the explanatory variables were included in the analyses for all sub-areas.

Table D1.7. Index for the month and CDFG block aggregated CPFV delta-gamma CPUE standardization (see Figure D1.17 for area definitions).

Year	nn	no	ncn	co	scn	sn	so	mex
1936	0.0080		0.0135		0.0280			
1937	0.0089		0.0072		0.0122			
1938	0.0632		0.0097		0.0081	0.0009		
1939	0.0410		0.0137		0.0157			
1940	0.1214		0.0083		0.0123	0.0024		
1941								
1942								
1943								
1944								
1945								
1946								
1947	0.0103		0.0318	0.0021	0.0047	0.0022	0.0021	0.0212
1948	0.0175	0.0043	0.0389	0.0128	0.0200	0.0034	0.0081	0.0363
1949	0.0156	0.0117	0.0254	0.0101	0.0138	0.0057	0.0064	0.0639
1950	0.0237	0.0206	0.0401	0.0178	0.0178	0.0021	0.0071	0.0472
1951	0.0178	0.0014	0.0230	0.0138	0.0313	0.0053	0.0140	0.0134
1952	0.0236	0.0677	0.0290	0.0219	0.0236	0.0047	0.0141	0.0166
1953	0.0239	0.0325	0.0332	0.0055	0.0282	0.0022	0.0118	0.0058
1954	0.0194	0.0231	0.0375	0.0146	0.0211	0.0023	0.0094	0.0063
1955	0.0047	0.0008	0.0330	0.0102	0.0615	0.0024	0.0556	0.0199
1956	0.0067	0.0023	0.0221	0.0296	0.0146	0.0010	0.0224	0.0168
1957	0.0040	0.0040	0.0154	0.0093	0.0068	0.0017	0.0081	0.0047
1958	0.0012	0.0010	0.0112	0.0017	0.0063	0.0012	0.0070	0.0005
1959	0.0010	0.0144	0.0101	0.0036	0.0049	0.0011	0.0066	0.0028
1960	0.0093	0.0077	0.0139	0.0051	0.0134	0.0010	0.0091	0.0050
1961	0.0040	0.0010	0.0609	0.0103	0.0213	0.0026	0.0126	0.0173
1962	0.0036	0.0021	0.0343	0.0076	0.0263	0.0074	0.0072	0.0123
1963	0.0042	0.0005	0.0443	0.0060	0.0405	0.0095	0.0088	0.0626
1964	0.0150	0.0052	0.0519	0.0125	0.0750	0.0141	0.0272	0.0391
1965	0.0152	0.0075	0.0490	0.0078	0.0560	0.0118	0.0240	0.0466
1966	0.0060	0.0070	0.0480	0.0089	0.0802	0.0083	0.0143	0.0448
1967	0.0118	0.0251	0.0410	0.0084	0.0650	0.0095	0.0108	0.0915
1968	0.0140	0.0078	0.0362	0.0074	0.0690	0.0137	0.0126	0.0613
1969	0.0078	0.0035	0.0338	0.0064	0.0597	0.0110	0.0083	0.1009
1970	0.0048	0.0030	0.0545	0.0043	0.0740	0.0268	0.0134	0.0479
1971	0.0058	0.0038	0.0783	0.0086	0.1174	0.0156	0.0149	0.0570
1972	0.0055	0.0039	0.0398	0.0099	0.1102	0.0080	0.0089	0.0224
1973	0.0076	0.0016	0.0730	0.0275	0.0859	0.0091	0.0125	0.0241
1974	0.0030	0.0013	0.0690	0.0248	0.1560	0.0040	0.0210	0.0677
1975	0.0025	0.0077	0.0625	0.0405	0.1091	0.0042	0.0357	0.0987
1976	0.0029	0.0002	0.0319	0.0646	0.0505	0.0049	0.0221	0.0403
1977	0.0020	0.0137	0.0849	0.0176	0.0379	0.0069	0.0243	0.0427
1978	0.0054	0.0039	0.0374	0.0075	0.0359	0.0147	0.0226	0.0434
1979								
1980	0.0081	0.0139	0.0643	0.0143	0.0235	0.0191	0.0463	0.0580
1981	0.0069	0.0196	0.0535	0.0151	0.0157	0.0198	0.0472	0.0306

1982	0.0080	0.0346	0.0418	0.0413	0.0188	0.0248	0.0556	0.0400
1983	0.0119	0.0074	0.0312	0.0192	0.0106	0.0153	0.0363	0.0357
1984	0.0051	0.0018	0.0403	0.0612	0.0152	0.0175	0.0435	0.0200
1985	0.0074	0.0077	0.0685	0.0257	0.0283	0.0456	0.0371	0.0164
1986	0.0155	0.0041	0.0686	0.0572	0.0212	0.0293	0.0306	0.0672
1987	0.0130	0.0110	0.0608	0.0143	0.0460	0.0236	0.0446	0.0300
1988	0.0195	0.0191	0.1204	0.0199	0.0607	0.0326	0.0469	0.0215
1989	0.0274	0.0333	0.1829	0.0420	0.0442	0.0430	0.0308	0.0616
1990	0.0217	0.0269	0.1271	0.0468	0.0630	0.0591	0.0429	0.0662
1991	0.0195	0.0398	0.1375	0.0649	0.0781	0.1039	0.0568	0.1221
1992	0.0148	0.0306	0.0472	0.0390	0.0448	0.0289	0.0370	0.0643
1993	0.0185	0.0265	0.0600	0.0479	0.0277	0.0283	0.0415	0.0865
1994	0.0303	0.0544	0.0834	0.0512	0.0612	0.0287	0.0403	0.1125
1995	0.0249	0.0352	0.0834	0.0319	0.0766	0.0418	0.0292	0.0870
1996	0.0332	0.0263	0.1143	0.0320	0.0844	0.0414	0.0167	0.0521
1997	0.0285	0.0254	0.0730	0.0263	0.0633	0.0755	0.0149	0.0478
1998	0.0299	0.0374	0.1082	0.0268	0.0421	0.0426	0.0094	0.0430
1999	0.0341	0.0270	0.2152	0.0382	0.0697	0.0840	0.0108	0.0658
2000	0.0366	0.0143	0.1734	0.0259	0.0699	0.0960	0.0103	0.0376
2001	0.0263	0.0367	0.1364	0.0461	0.0681	0.1045	0.0237	0.1012
2002	0.0145	0.0315	0.0720	0.0110	0.0433	0.0499	0.0082	0.0669
2003	0.0093	0.0148	0.0743	0.0027	0.0362	0.0346	0.0067	0.0851
2004	0.0035	0.0021	0.0427	0.0023	0.0304	0.0227	0.0028	0.0350

RecFIN CPFV species association

A major problem with CPUE analysis is determining if a data point should be included in the analysis. If a unit of effort has no chance of catching the species of interest, it should not be included in the analysis. For example, trips that focus solely on tuna will not catch California scorpionfish. However, it is often difficult to determine targeting of a trip. If the targeting changes over time this will bias the index of abundance derived from the CPUE analysis. We used a logistic regression method of Stephens and MacCall (2004) to determine the probability of catching California scorpionfish based on the presence of other species of fish in the catch. The association of other species is given in Figure D1.18.

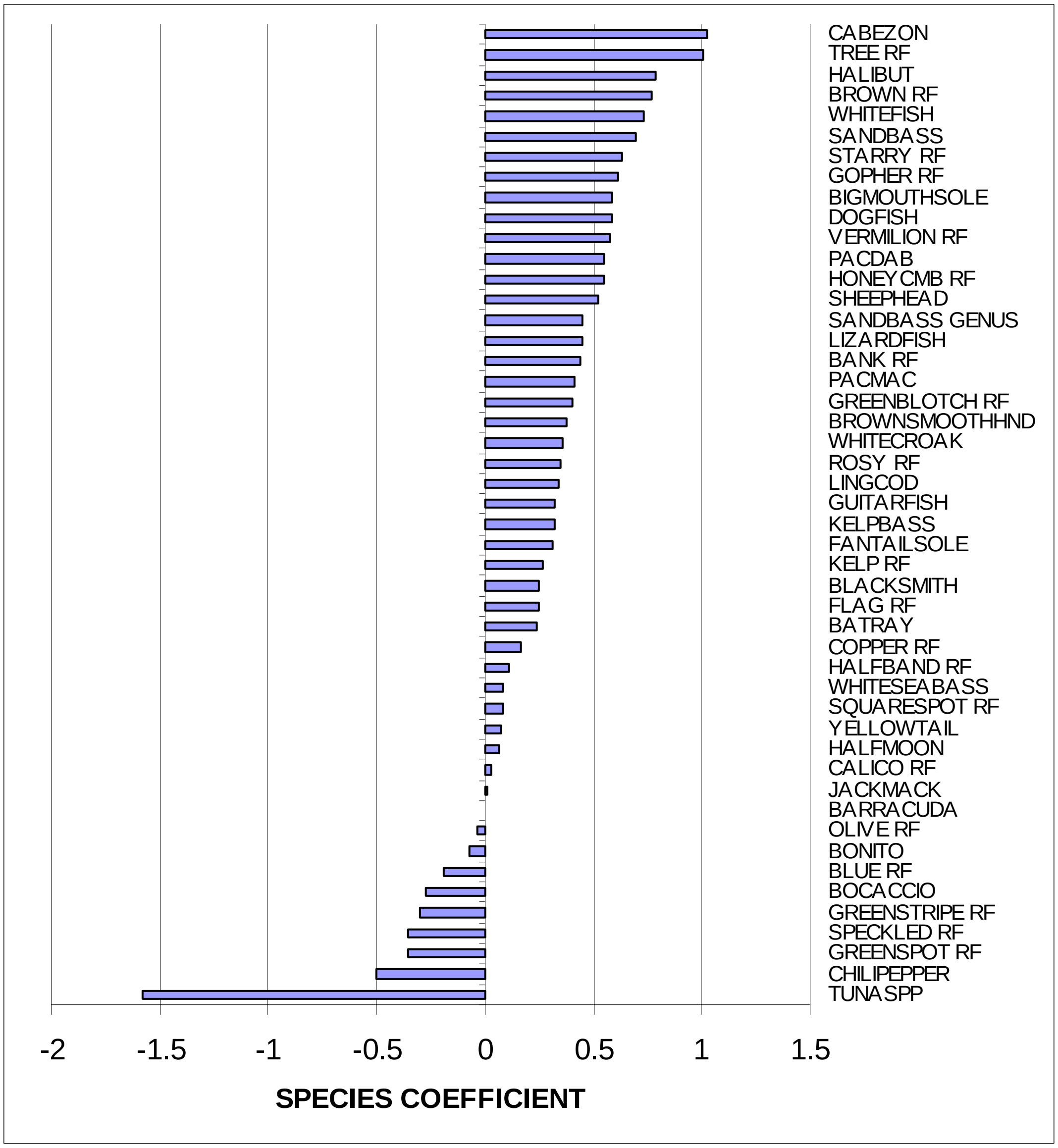


Figure D1.18. The association of species of fish with California scorpionfish in the CPFV catch from the RecFIN database.

We applied a delta-gamma regression to the data records that were determined to have at least a 31% probability of capturing a California scorpionfish. The cutoff was based on the logistic regression recommended threshold probability. Initial analyses suggested the results were not sensitive to this cutoff. Data are available from 1980-2003 with a hiatus in 1990-1992. The catch in numbers per angler hour fished was regressed against year, month, and a dummy variable indicating if the fishing was inside or outside the 3 mile line. Separate regressions were carried on for San Diego, Orange, and Los Angeles counties and for Santa Barbara and Ventura counties combined. Based on the AIC criteria, Los Angeles and San Diego counties included all explanatory variables; Orange County and Santa Barbara-Ventura counties did not include month. The indices are given in table D1.8.

Table D1.8. Index and coefficient of variation for the RecFIN CPFV species association delta-gamma CPUE standardization.

	SD		ORG		LA		SB-VEN	
Year	Index	CV	Index	CV	Index	CV	Index	CV
1980	0.0079	0.37	0.0246	0.73	0.0892	0.80	0.0028	0.62
1981	0.0082	0.38	0.0127	0.34	0.0111	0.42	0.0063	0.63
1982	0.0174	0.28	0.0072	0.37	0.0387	0.54	0.0048	1.07
1983	0.0127	0.19	0.0110	0.64	0.0124	0.37		
1984	0.0142	0.19	0.0109	0.35	0.0168	0.34	0.0017	0.57
1985	0.0182	0.27	0.0329	0.40	0.0306	0.35	0.0019	0.66
1986	0.0186	0.32	0.0367	0.38	0.0177	0.31	0.0037	0.63
1987	0.0678	0.87	0.0145	0.62	0.0304	0.54		
1988	0.0302	0.33	0.1276	0.54	0.0497	0.48	0.0054	0.69
1989	0.0256	0.41	0.0208	0.87	0.1821	0.54	0.0267	0.42
1993			0.0185	0.84	0.0082	0.75		
1994			0.0082	0.60				
1995	0.0344	0.27	0.0611	0.78	0.0247	0.31	0.0067	0.62
1996	0.0523	0.43	0.1098	0.49	0.0346	0.34	0.0076	0.47
1997	0.0955	0.49	0.0585	0.46	0.0508	0.71	0.0154	0.67
1998	0.0995	0.32	0.0124	0.48	0.0198	0.40	0.0171	0.61
1999	0.1380	0.49	0.1141	0.54	0.0674	0.31	0.0087	0.29
2000	0.0804	0.22	0.0514	0.34	0.0952	0.46	0.0200	0.45
2001	0.0748	0.25	0.0174	0.48	0.0714	0.33	0.0139	0.45
2002	0.0946	0.32	0.0670	0.47	0.0662	0.41	0.0107	0.39
2003	0.1091	0.37	0.0796	0.36	0.1199	0.33	0.0082	0.32

<u>Trawl CPUE</u>

Trip records are available from trawl logbooks for the Northern Nearshore and the north Central Nearshore sub-areas. We used a delta-gamma model to regress California scorpionfish catch against the explanatory variables year, month, CDFG block, vessel id, and tow hours as explanatory variables. For both sub-stocks all variables except vessel id were selected using the AIC criteria. The indices and CVs are given in table D1.9.

Table D1.9. Indices of abundance and CVs for the trawl CPUE data.

	Northern Nearshore		north Central Nearshore	
Year	Index	CV	Index	CV
1985	0.1171	0.73		
1993	0.5812	0.77		
1994	0.3920	0.35		
1995	2.1694	0.34		
1996	1.5926	0.35		
1997	1.4878	0.34	18.6150	0.18
1998	0.7517	0.33	11.6147	0.24
1999	1.6335	0.29	5.3210	0.29
2000	1.0703	0.31	6.4487	0.40
2001	0.2100	0.32	4.3816	0.37
2002	0.0920	0.41	6.7141	0.73
2003	0.0140	0.52	5.0424	0.63

Impingement data

We were unable to obtain the impingement data in time for the assessment.

Sanitation surveys

The sanitation districts of the counties in southern California carry out trawl surveys to monitor the effects of the sewer outfalls. These surveys record the number of California scorpionfish captured and, usually, measure the length of the fish. The lengths are measured in standard length. Data are available from Palos Verdes, Hyperion, Orange County, and San Diego. An index for the southern California stock was created by scaling the indices to have the same average for the overlapping period and then taking the average weighted by the inverse of the variance. Indices of abundance and CVs are given in Table D1.10.

Table D1.10. Index value and CV for the Sanitation District surveys.

	ORG		Hyperion		Palos Verdes		San Diego		Combined	
Year	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV
1970	0.89	0.82							0.30	0.82
1971	0.6	0.52							0.20	0.52
1972	1.35	0.55			0.13	0.73			0.33	0.46
1973	2.49	0.54			0.22	0.61			0.54	0.42
1974	0.95	0.56			0.14	0.48			0.30	0.37
1975	1.15	0.36			0.1	0.77			0.31	0.34
1976	0.9	0.43			0.15	0.61			0.31	0.35
1977	1.21	0.32			0.35	0.36			0.47	0.24
1978	2.17	0.21			0.07	0.7			0.33	0.26
1979	2.73	0.28			0.85	0.22			1.19	0.18
1980	2.74	0.27			0.99	0.28			1.12	0.21
1981	2.14	0.3			1.64	0.26			0.88	0.24
1982	3.66	0.71			2.01	0.36			2.00	0.38
1983	0.42	0.4			0.71	0.34			0.16	0.35
1984	0.87	0.52			0.14	0.48			0.29	0.35
1985	1.07	0.33			0.4	0.32	0.13	0.86	0.19	0.31
1986	1.47	0.48			0.59	0.37	0.35	0.59	0.33	0.33
1987	3.48	0.39	2.86	0.77	0.73	0.25	0.37	0.90	0.64	0.26
1988	5.84	0.32	1.06	0.53	0.42	0.34	2.20	0.42	0.96	0.21
1989	2.51	0.41	1.32	0.39	0.22	0.36	2.26	0.31	0.65	0.20
1990	2.53	0.44	1.77	0.44	0.39	0.34	1.48	0.30	0.88	0.18
1991	2.38	0.47	0.39	0.53	0.16	0.39	0.73	0.52	0.33	0.25
1992	1.26	0.45	0.13	1.07	0.21	0.33	0.81	0.24	0.28	0.21
1993	1.6	0.31	1.37	0.41	0.18	0.38	1.22	0.20	0.56	0.15
1994	2.48	0.47	1.55	0.46	0.28	0.34	0.83	0.30	0.58	0.19
1995	1.21	0.52	1.79	0.3	0.46	0.28	1.45	0.21	0.78	0.15
1996	1.84	0.53	2.34	0.24	0.47	0.24	1.96	0.20	1.05	0.13
1997	4.55	0.46	2.01	0.29	0.76	0.25	1.21	0.24	0.97	0.15
1998	3.11	0.54	1.19	0.33	0.52	0.29	1.58	0.21	0.92	0.15
1999	2.54	0.38	2.08	0.27	0.33	0.31	3.13	0.16	1.07	0.13
2000	4.02	0.39	1.9	0.31	0.32	0.37	2.29	0.19	1.05	0.15
2001	3.15	0.33	2.14	0.24	0.67	0.42	2.20	0.17	1.29	0.12
2002	3.45	0.52	1.37	0.38	1.77	0.91	1.14	0.23	0.76	0.19
2003	4.05	0.82	1.78	0.36	0.5	0.48	2.88	0.31	1.25	0.21
2004			2.55	0.28	0.86	0.49	2.09	0.39	1.50	0.21

<u>Hyperion</u>

Only the stations with a reasonable time series and catches of scorpionfish were used in the analysis (stations A1, A3, C1-C6, C9, C9A, D1, D1T, HT10-HT11, Z2-Z3). A delta-gamma model is used to regress catch in numbers per tow versus the explanatory variables year, month and station. A binomial model is used to model the proportion positive and a gamma model is used to model the distribution of positive observations. The same explanatory variables are used in both the binomial and gamma components of the model. A combined year effect from the binomial and gamma models is used to represent the relative abundance. A jackknife procedure is used to calculate standard errors for the year effects. The analysis was carried out using the R code provided by E.J. Dick. The best model based on the AIC criterion included all explanatory variables. The index values and CVs are given in table D1.10.

Orange County

Only the stations with a long time series of years were used in the analysis (stations T0-T6 and T10-T11). A delta-gamma model is used to regress catch in numbers per tow versus the explanatory variables year, month and station. A binomial model is used to model the proportion positive and a gamma model is used to model the distribution of positive observations. The same explanatory variables are used in both the binomial and gamma components of the model. A combined year effect from the binomial and gamma models is used to represent the relative abundance. A jackknife procedure is used to calculate standard errors for the year effects. The analysis was carried out using the R code provided by E.J. Dick. The best model based on the AIC criterion included all explanatory variables. The index and CVs are given in table D1.10.

Palos Verdes

Most of the stations were sampled every year so all the stations were used in the analysis. A delta-gamma model is used to regress catch in numbers per tow versus the explanatory variables year, month and station. A binomial model is used to model the proportion positive and a gamma model is used to model the distribution of positive observations. The same explanatory variables are used in both the binomial and gamma components of the model. A combined year effect from the binomial and gamma models is used to represent the relative abundance. A jackknife procedure is used to calculate standard errors for the year effects. The analysis was carried out using the R code provided by E.J. Dick. The best model based on the AIC criterion included all explanatory variables. The index values and CVs are given in table D1.10.

San Diego

A delta-gamma model is used to regress catch in numbers per tow versus the explanatory variables year, quarter and station. A binomial model is used to model the proportion positive and a gamma model is used to model the distribution of positive observations. The same explanatory variables are used in both the binomial and gamma components of the model. A combined year effect from the binomial and gamma models is used to represent the relative abundance. A jackknife procedure is used to calculate standard errors for the year effects. The analysis was carried out using the R code provided by E.J. Dick. The best model based on the AIC criterion included all explanatory variables. The index values and CVs are given in table D1.10.

CalCOFI Surveys

UCSD Scripps Institution of Oceanography, CDFG, and the National Marine Fisheries Service have carried out a plankton survey on a regular basis since 1951 (Moser et al. 1993). Unfortunately, larvae for Scorpaena have not been identified to the species level. Dr William Watson of NMFS SWFSC looked at Scorpaena larvae from Mexican waters on CalCOFI cruises 5707, 6608, and 8108. Based on these samples, *S. guttata* larvae occur at least as far south as Punta San Juanico (line 133), and other Scorpaena larvae occur as far north as Punta Abreojos (line 130). Adult *S. guttata* are reported to occur as far south as Punta Abreojos; other species in the south are *S. sonorae* that has been reported to occur as far north as the Bahia Magdalena/Punta Marquis vicinity on the outer coast (about CalCOFI line 147); S. histrio as far north as Cabo San Lucas vicinity; and S. mystes, which ranges north either to the Cabo San Lucas vicinity, or else to California, depending on the source (pers. com Dr William Watson of NMFS SWFSC). It appears that Scorpaena spp. larvae south to at least line 133 are mostly (> 95%) *S. guttata* or are consistent with *S. guttata* (pers. com Dr William Watson of NMFS SWFSC).

The CalCOFI bongo tows have 308 tows positive for Scorpaena, 8 of which were identified as *S. guttata*. Two hundred eighty-eight of these occur at line 133 or further north. The standardized count per tow has a large variation with the highest being 3416. This occurred at line 127 in August 1956. The CalCOFI manta tows have 10 tows positive for Scorpaena all of which were identified as *S. guttata* (1981 = 5, 1984 = 1, 1990 = 1, 1992 = 1, 1994 = 1). Only data from the bongo tows are used in this analysis. The CalCOFI cruses stopped covering Mexican waters in 1985 and we were unable to obtain the equivalent data from the Mexican survey in time for the assessment. Scorpaena were not identified in the survey before 1956. Therefore, we use data from 1956 to 1984 in this analysis. We use data including and north of line 133 and assume that this indicates the abundance of California scorpionfish.

The explanatory variables included year, month, latitude, latitude squared, station, and station squared. A binomial error was used for the proportion positive and a lognormal error structure was used to model the positive tows. Based on the AIC criteria, the best model included all the explanatory variables. The year 1968 only had one positive and this could not be used to generate jackknife estimates of uncertainty. The jackknife procedure was too computationally intensive to run, so confidence intervals were not calculated. The index is given in table D1.11.

This index is mainly for biomass that spawns off Mexico. It is possible that either adults from off the US coast migrate to Mexican waters to spawn or that the larvae are moved by the currents from off the coast of the US into Mexican waters.

Table D1.11. Abundance index from the CalCOFI survey.

Year	Index
1956	0.1337
1957	0.1750
1958	0.0133
1959	0.0351
1960	0.0628
1961	0.0955
1962	0.0948
1963	0.0786
1964	0.0412
1965	0.0552
1966	0.1325
1967	0.1122
1968	0.2806
1969	0.0821
1972	0.1192
1975	0.2001
1978	0.0415
1981	0.0898
1984	0.0000

Comparison of abundance indexes

The abundance indices from the CPFV trip data and the data summarized by month and CDFG bock are essentially the same for the years that overlap. The indices from the RecFIN species association data show the same trends (Figure D1.19), but have much more uncertainty than the other two indices. Therefore, they are not considered for the assessment. There is substantial variation in the targeting of the CPFV fleet (Figure D1.20). In the late 1950s the proportion of trips that caught highly migratory species greatly increased and then decline to the mid 1970s.

The CalCOFI index shows a similar trend to the CPFV CPUE index for the Mexican area except for the first two data points (Figure D1.21).

Due to the short period of the trawl CPUE indices and the management changes that occurred in the late 1990s and early 2000s, comparisons with the CPFV are not appropriate.

The inter-annual variation of the Hyperion sanitation index and the north Central Nearshore CPFV CPUE index has some similarities, but differs in more recent years where management regulations may have influenced the CPUE (Figure D1.22).

The Orange County Sanitation District survey index shows the same general upward trend as the CPFV CPUE index for the south Central Nearshore area over the period 1980 to 1999 (Figure D1.22). However, the inter-annual variations are different. The differences after 1999 could be due to management measures introduced at this time. There are large differences between the two indices before 1980.

The Palos Verdes sanitation index differs substantially from the north Central Nearshore CPFV CPUE index (Figure D1.22).

The San Diego sanitation index is similar to the Southern Nearshore CPFV index (Figure D1.22).

The sanitation indices all show similar trends, with an increase since the early 1990s (Figure D1.23).

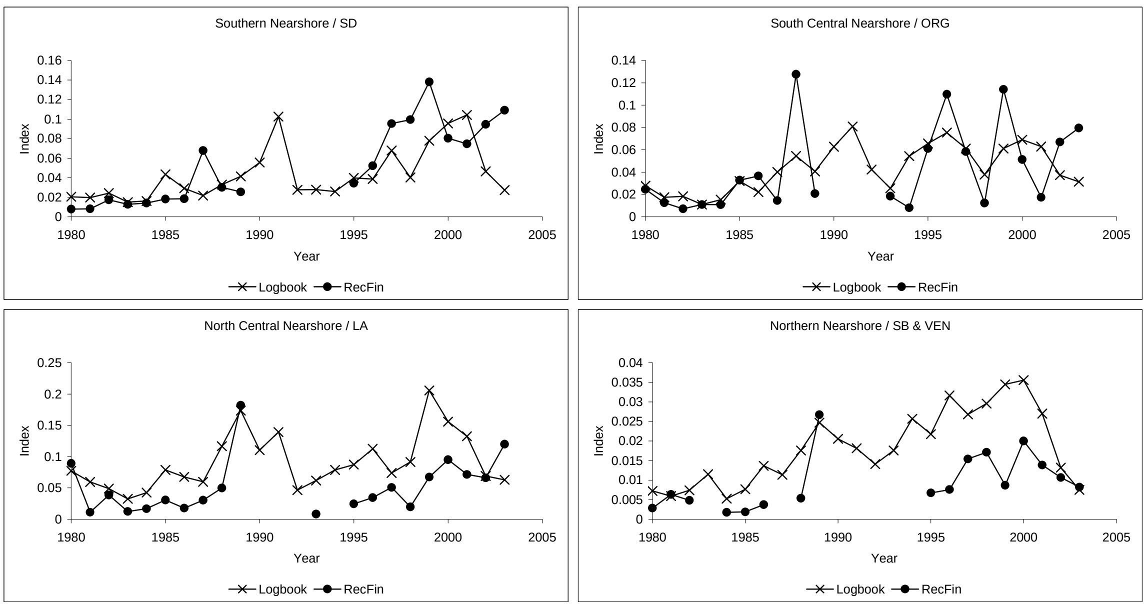


Figure D1.19. Comparison of species composition RecFIN CFPV CPUE indices with CPFV logbook CPUE indices.

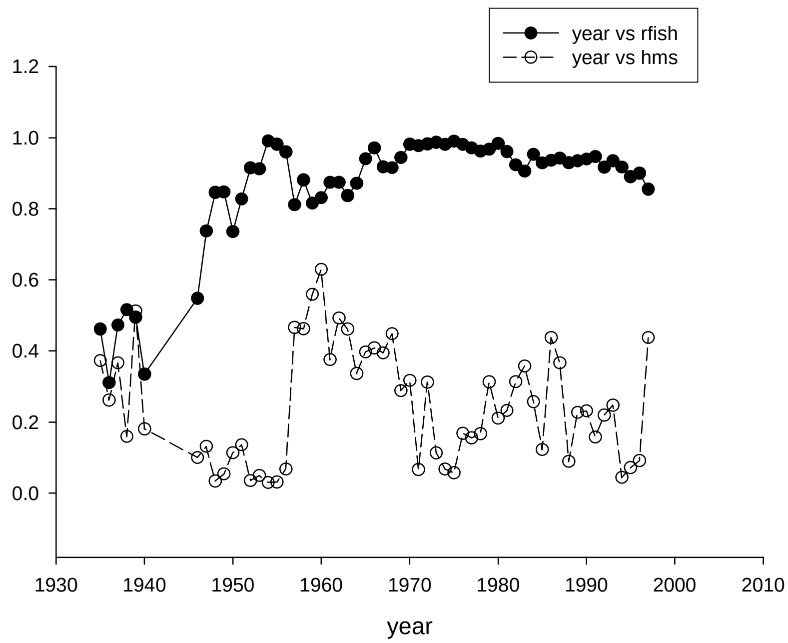


Figure D1.20. Proportion of trips that had positive catches of rockfish (rfish) and highly migratory species (hms).

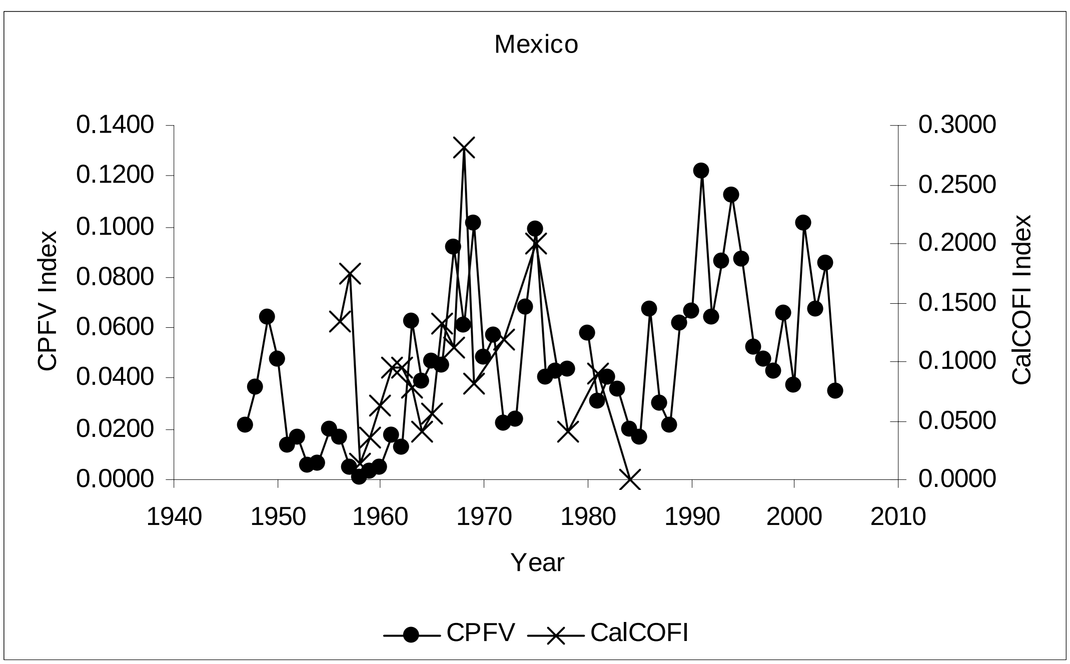


Figure D1.21. Comparison of the CPFV CPUE index from the Mexican area with the CalCOFI survey index.

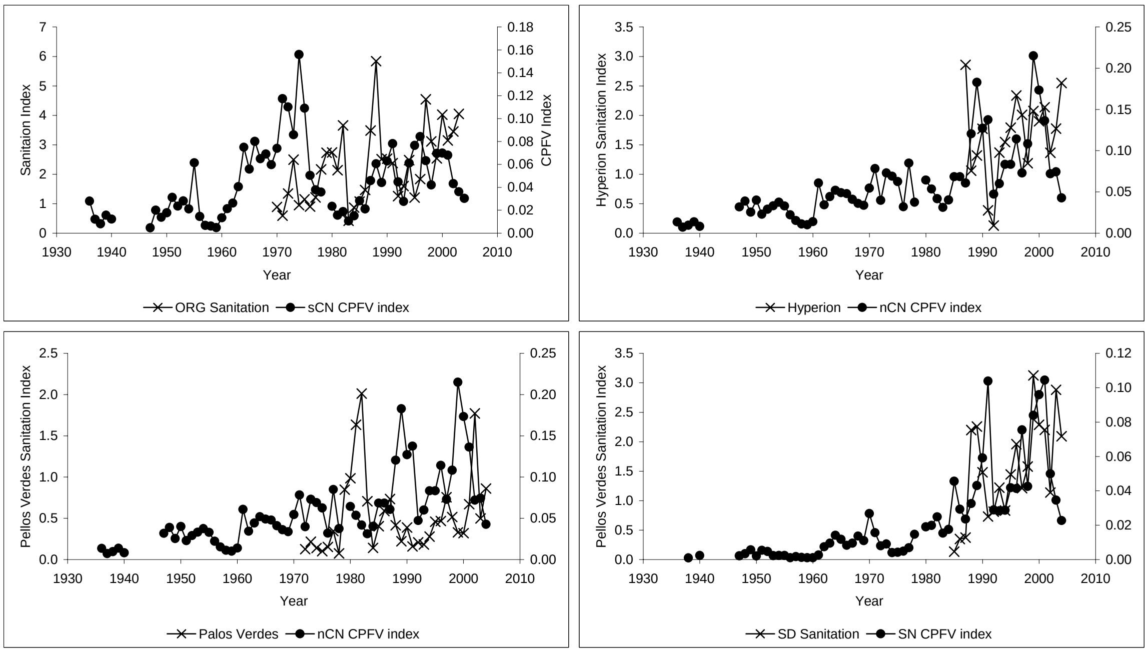


Figure D1.22. Comparison of the CPFV CPUE indices with the sanitation survey indices.

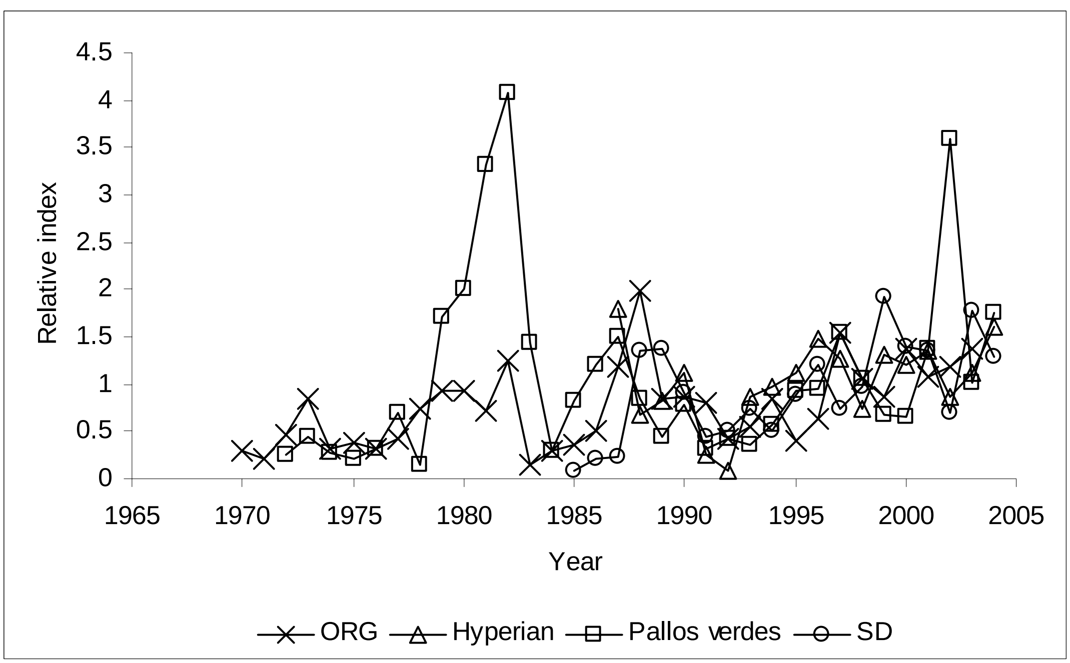


Figure D1.23. Comparison of the sanitation survey indices.

2. History of modeling approaches

This is the first time that California scorpionfish has been assessed. No previous stock assessment models are available for this species.

3. Model Description

The stock assessment is carried out using Stock Synthesis II version 1.18 (SS2; Methot 2005 [SS2 version 1.19 was used to update the MSY quantities]). SS2 is an age-structured statistical stock assessment model programmed in AD Model Builder (http://otter-rsch.com/admodel.htm). SS2 is general, fits to multiple data types, and allows for a range of assumptions about the dynamics of the population and the fisheries. We chose to use a sex-structured model to allow for the differences in the growth rates between males and females (love et al. 1987). Age 25 is used as a plus group to accumulate all older fish and the biological characteristics for all fish in this group are assumed to be the same. In general, the model is fit to catch-at-length data and abundance indices. The stock is modeled from a virgin (unexploited) population in 1916. There is no catch-at-length data for the fish pot fishery and we assume that the selectivity for this gear is the same as the hook and line fishery. The gillnet fishery catches larger fish than all the other fisheries, but comes from a limited spatial area. Therefore, we set the selectivity of the gillnet fishery to that of the hook and line fishery and excluded the gillnet length-frequency data from the analysis. All the selectivities are length-based and it is assumed that this length based selectivity is the same for males and females. However, because males and females have different mean lengths at age, males and females will have different age-specific selectivities. Due to changes in the minimum legal size, two time blocks are used for the commercial and recreational fisheries. For the recreational fisheries they are 1916-1999 and 2000-2004. For the commercial fisheries they are 1916-1998 and 1999-2004. Length data are recorded as total length (TL, or equivalently fork length) to the nearest millimeter for all the fisheries. The sanitation survey data are measured in standard length (SL) and often to the nearest centimeter. Conversion from centimeter SL bins to TL causes problems with clumping of data, therefore we convert all data and parameters into SL and use SL as the basis for the analysis. One centimeter bins from 1 to 59 (lower bounds of bins) are used to represent the catch-at-length data. Selectivity curves for all fisheries are assumed to be asymptotic and modeled using the SS2 double logistic. The selectivity for the lowest length bin is set close to zero, the peak is set to the largest length bin, the selectivity for the oldest length bin is set close to 1, and the slope and inflection point of the left hand limb are the only parameters estimated. Catch and catch-at-length data from the CPFV and private recreational boats are combined into a single fishery. The commercial catch is included in the model in tons and the recreational catch is included in the model in thousands of fish. Mean length at age is taken from the growth equation estimated by Love et al. (1987) converted into standard length and the coefficient of variation for length at age is assumed as 0.05.

The biological parameters used in the SS2 assessments were converted to SL from TL (Table D3.1). SS2 uses a logistic function to represent maturity at length and a linear regression for eggs per kilogram. This does not correspond to the maturity and fecundity data for scorpionfish (see above). Therefore, we combine the GSI (grams of eggs/grams of weight) and the maturity schedule into a single maturity schedule by fitting the logistic function (Figure D3.1).

Table D3.1. Biological parameters used in SS2 based on SL.

Parameter	Female	Male
SL(1)	10.727	12.467
SL(25)	34.560	28.151
K	0.130	0.120
SL_a	0.053	0.056
SL_b	2.911	2.902
Mat_slope	-0.466	
Mat_int	17.188	

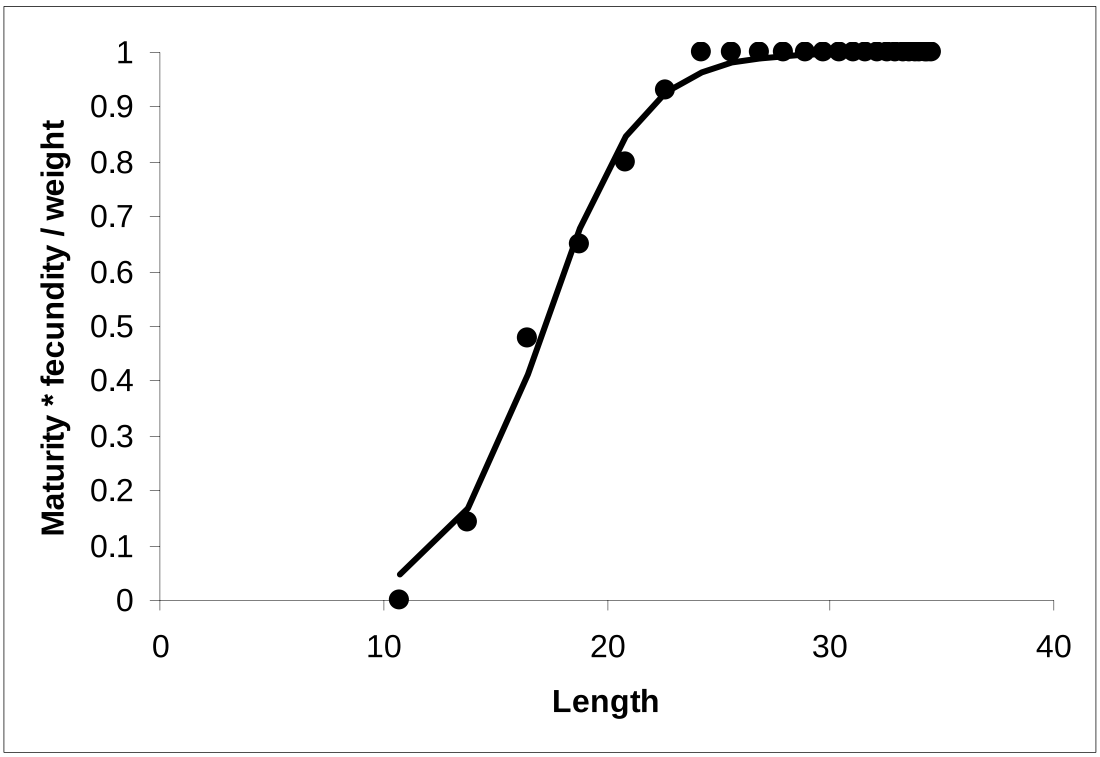


Figure D3.1. The maturity schedule used in SS2 developed by fitting the logistic function to the GSI*maturity at length.

There are six candidate indices of abundance, but only the trip based CPFV CPUE and the sanitation indices are used.

1) Trawl CPUE. Due to management restrictions on the commercial fishery that were initiated in 1999, the trawl survey CPUE index is not considered a reliable index of abundance and is not use in the analysis.

2) CPFV CPUE based on trip records, 1980-2003. This index is considered a reasonable representation of the abundance for years prior to the implementation of management restrictions in 2000, and these years are used in the analysis. The index was included in the model as an index of number of fish.

3) CPFV CPUE based on month and CDFG block summarized data 1936-2004. The years 1980 – 2003 are duplicates of the CPFV CPUE based on trip records and it is thought that earlier data may be influenced by changes in technology and targeting. Therefore, this index is not included in the analysis.

4) CPFV CPUE based on RecFIN data and species association selection of records. These data were not used because it shows similar trends to the trip based CPUE, but has much larger CVs.

5) The sanitation surveys. These fishery independent surveys are thought to be a reasonable representation of the abundance and used in the analysis. The four indices were combined to form a single index. The index was included in the model as a an index of number of fish.

Catch-at-length data are available from the commercial, recreational, and sanitation surveys.

Catch-at-age data are available from the biological studies of Love et al. (1987). These data are from trawls around the Palos Verdes area. Due to the limited spatial coverage and the opportunistic sampling, the data are assumed to be inappropriate to include in the analysis.

The steepness of the Beverton-Holt stock-recruitment relationship is assumed equal to 0.7, the natural mortality is assumed equal to 0.25 for both sexes, and the coefficient of variation of length at age is assumed equal to 0.05. The model estimates the virgin recruitment, the catchability coefficients for the CPFV trip CPUE index and the sanitation survey indices, annual recruitment deviates for 1966 to 2001,and the slope and inflection point of the logistic selectivity curve for the hook and line, gillnet, trawl, recreational, and sanitation survey logistic selectivity curves (two time periods of selectivities for the fisheries).

4. Model selection and evaluation

5. Base run results

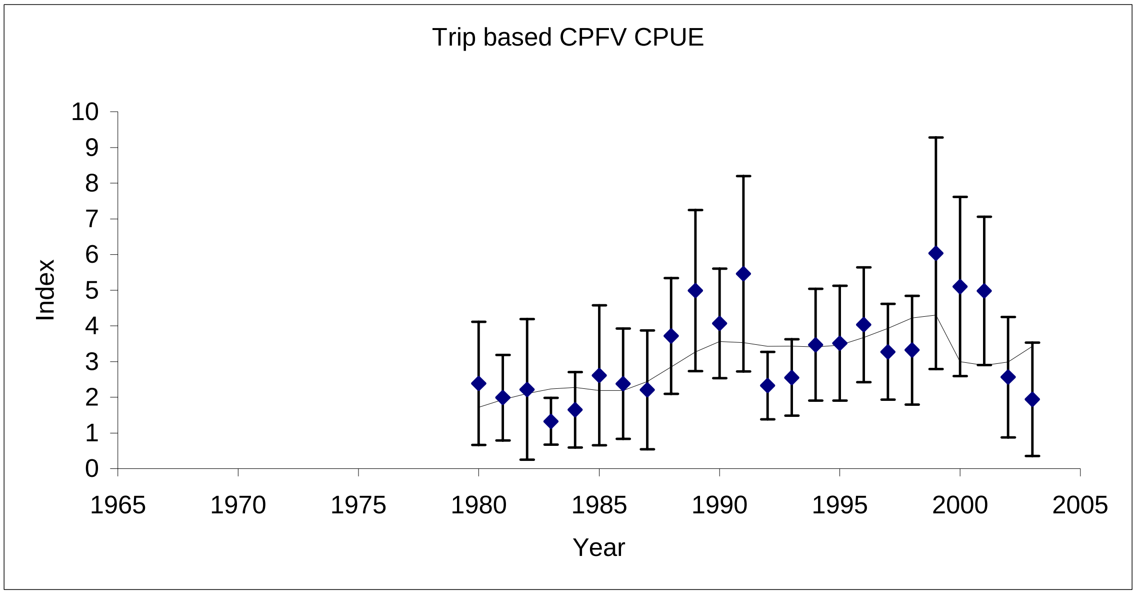
The model provides a reasonable fit to both the indices of abundance used in the model (Figure D5.1). The model generally fits the length-frequency data well, except for the gillnet data which is not included in the objective function and the selectivity for this gear is assumed to be the same as the hook and line fishery (Figure D5.2). There are some outliers in the length-frequency data.

The spawning biomass is estimated to be 80% of the average unexploited population level (Figure D5.3, Table D5.1). Recruitment has been generally higher than average since the mid 1980s. The estimated selectivity curves are given in Figure D5.4 and show that the increase in minimum legal size has reduced the selectivity of small fish as expected.

The spawning biomass is reasonably well estimated (Figure D5.5) and there is no clear relationship between recruitment and the spawning stock size (Figure D5.6).

Table D5.1. Estimated quantities from the assessment.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Discards	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
Landings (mt)	133	154	178	163	261	209	198	110	94	81	
ABC											
OY									84.9	84.9	
With sanitation survey											
SPR	0.482	0.455	0.435	0.471	0.383	0.418	0.420	0.530	0.587	0.656	
Exploitation rate	0.129	0.155	0.180	0.153	0.254	0.185	0.175	0.098	0.085	0.071	
Summary (age 2+) biomass	1444	1611	1687	1703	1688	1635	1743	1803	1848	1864	1866
Spawning stock biomass	530	580	629	663	691	636	612	623	704	774	816
(cv)	0.03	0.03	0.03	0.03	0.04	0.05	0.07	0.09	0.09	0.10	0.10
Recruitment	3025	2652	2223	3261	4660	3474	2103	1930	1968	1996	
Depletion level	0.518	0.567	0.615	0.648	0.675	0.622	0.598	0.608	0.688	0.756	0.798
(cv)										0.10	0.10
Without sanitation survey											
SPR	0.510	0.489	0.470	0.506	0.410	0.457	0.456	0.561	0.590	0.622	
Exploitation rate	0.114	0.138	0.163	0.144	0.256	0.204	0.207	0.124	0.111	0.096	
Summary (age 2+) biomass	1676	1801	1933	1894	1830	1646	1522	1405	1376	1358	1352
Spawning stock biomass	609	680	738	771	788	700	631	564	557	557	563
(cv)	0.05	0.04	0.05	0.05	0.06	0.08	0.09	0.10	0.10	0.09	0.09
Recruitment	3997	1984	1905	1915	1924	1893	1865	1831	1827	1827	
Depletion level	0.623	0.695	0.755	0.788	0.805	0.715	0.645	0.577	0.569	0.569	0.576
(cv)										0.08	0.07



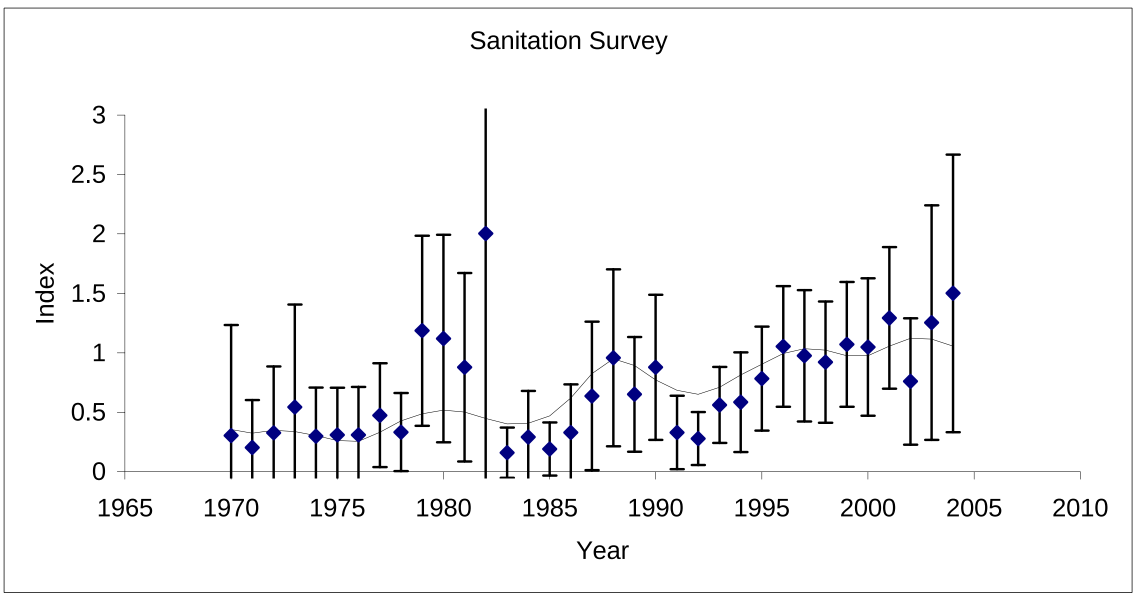


Figure D5.1a. Fit of the model to the indices of abundance.

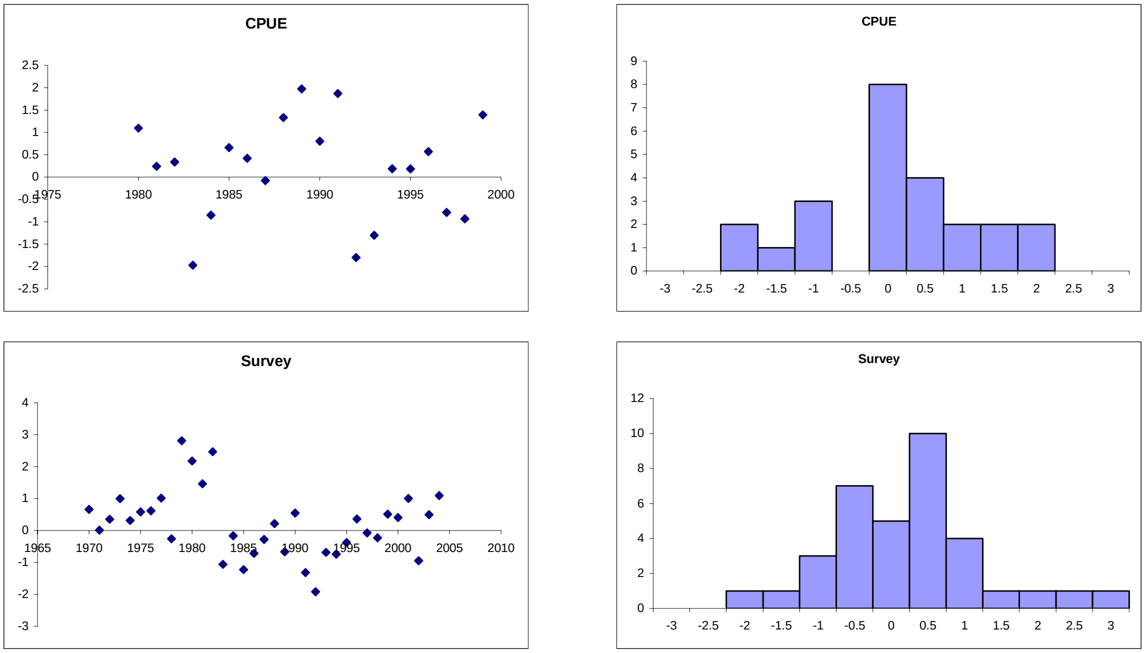


Figure D5.1b. Bias adjusted standardized residuals from the fit of the model to the indices of abundance.

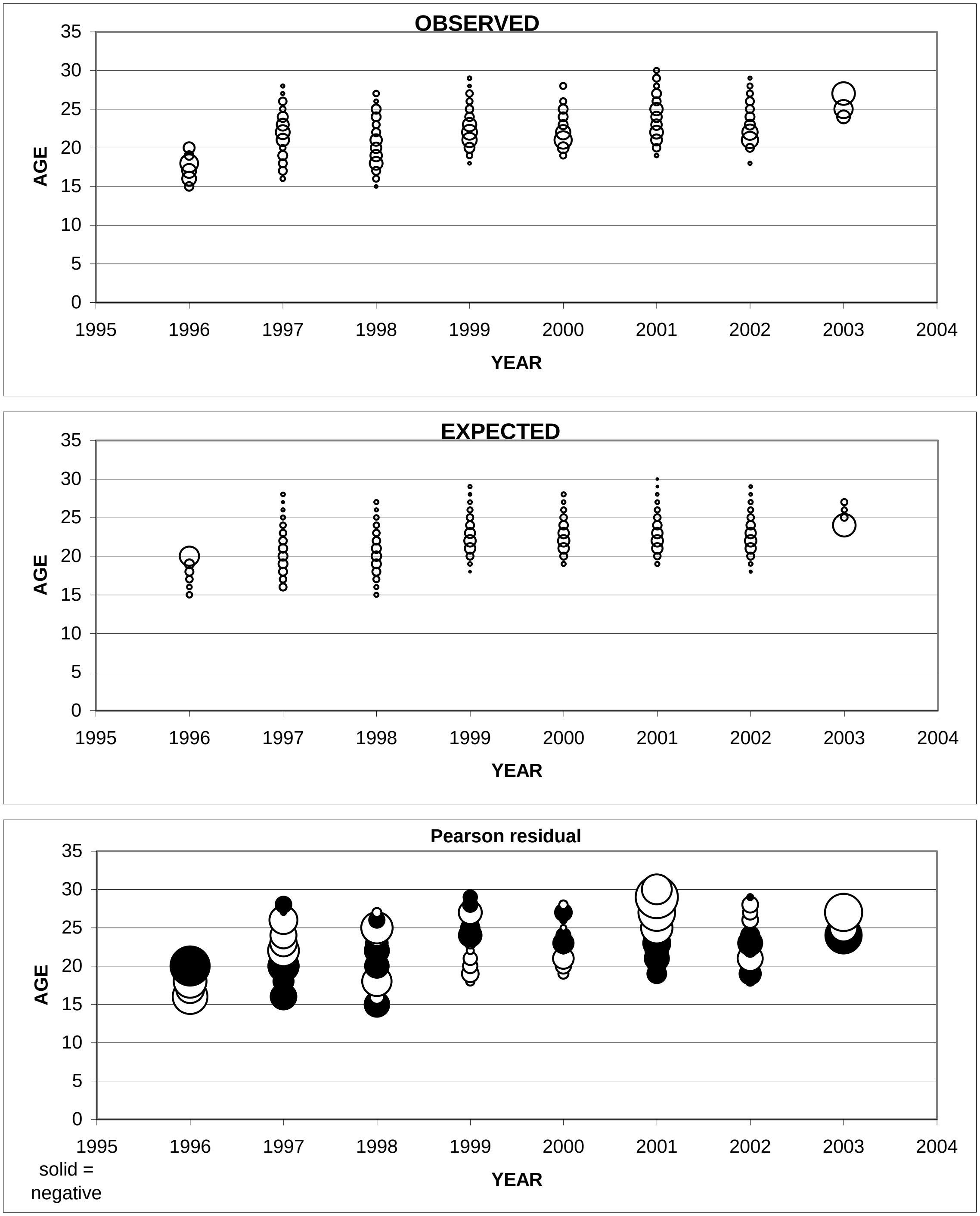


Figure D5.2a. Fit to the Hook and Line commercial length frequency data.

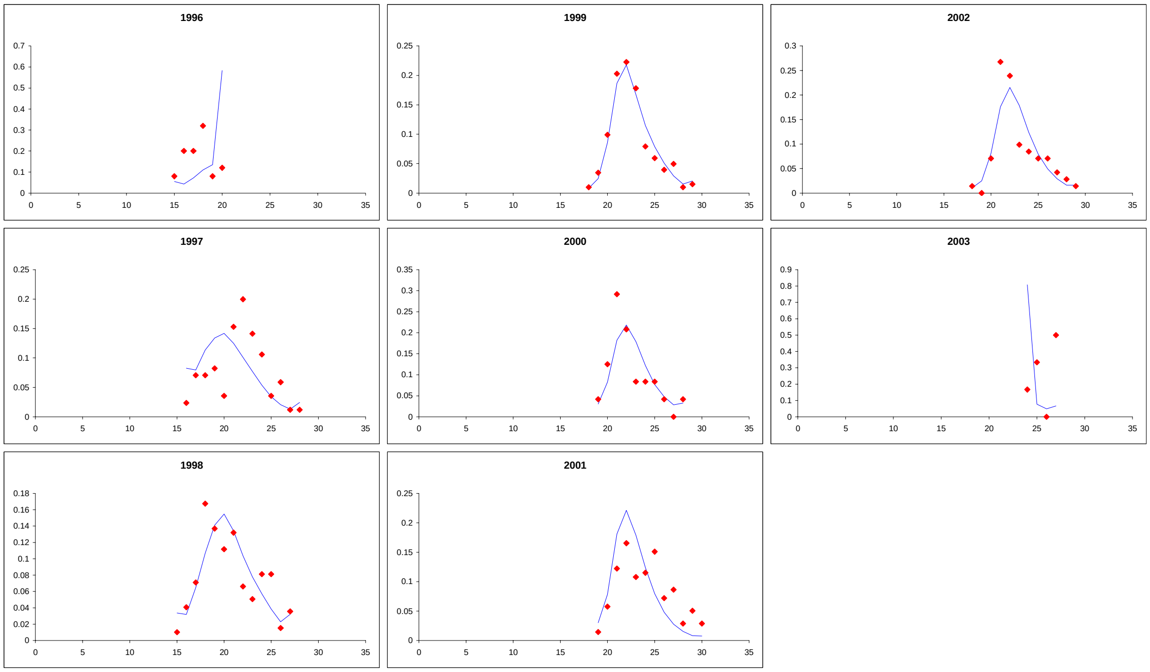


Figure D5.2a continued. Fit to the Hook and Line commercial length frequency data.

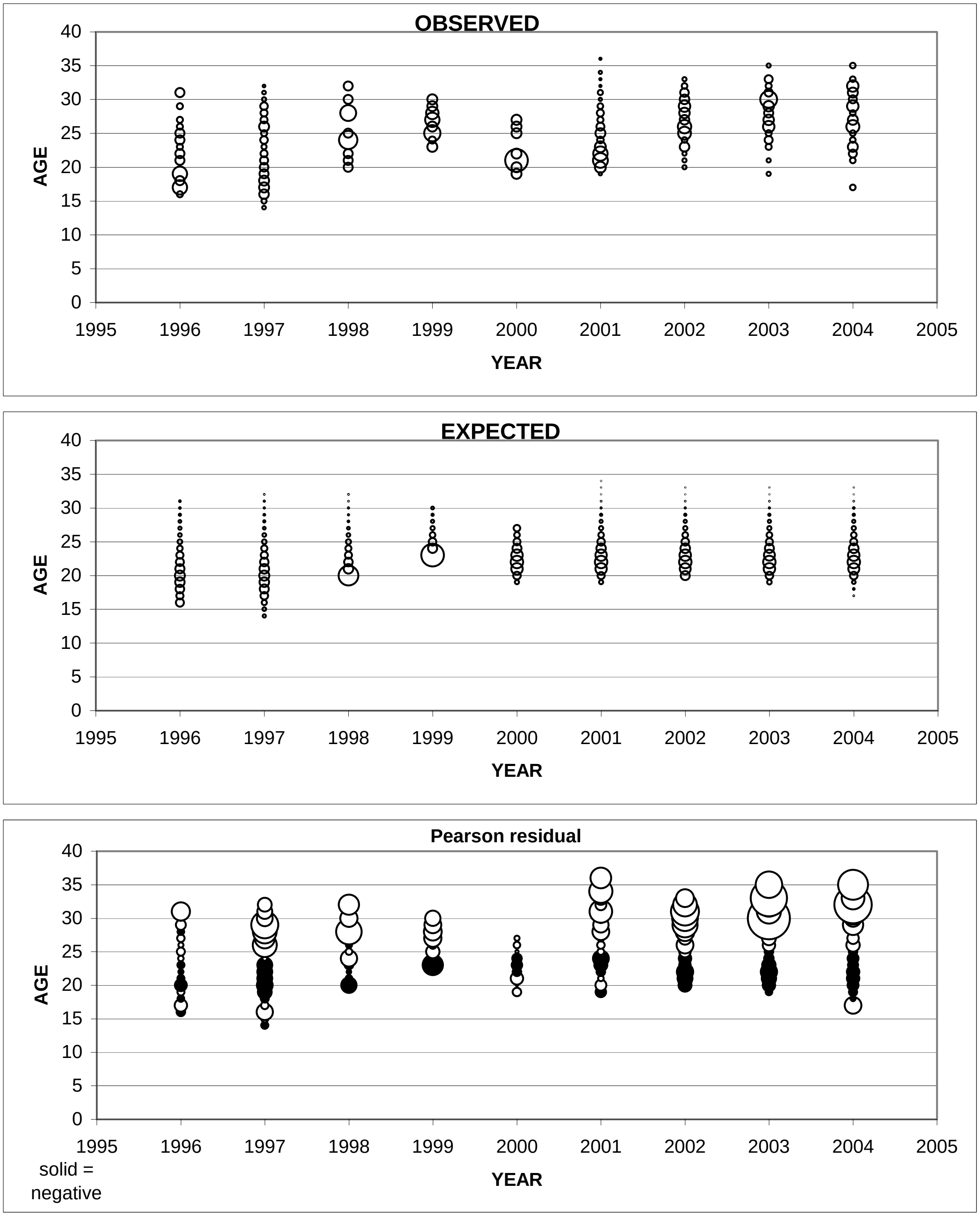


Figure D5.2b. Fit to the set net commercial length frequency data. Note that these data were not included in the objective function.

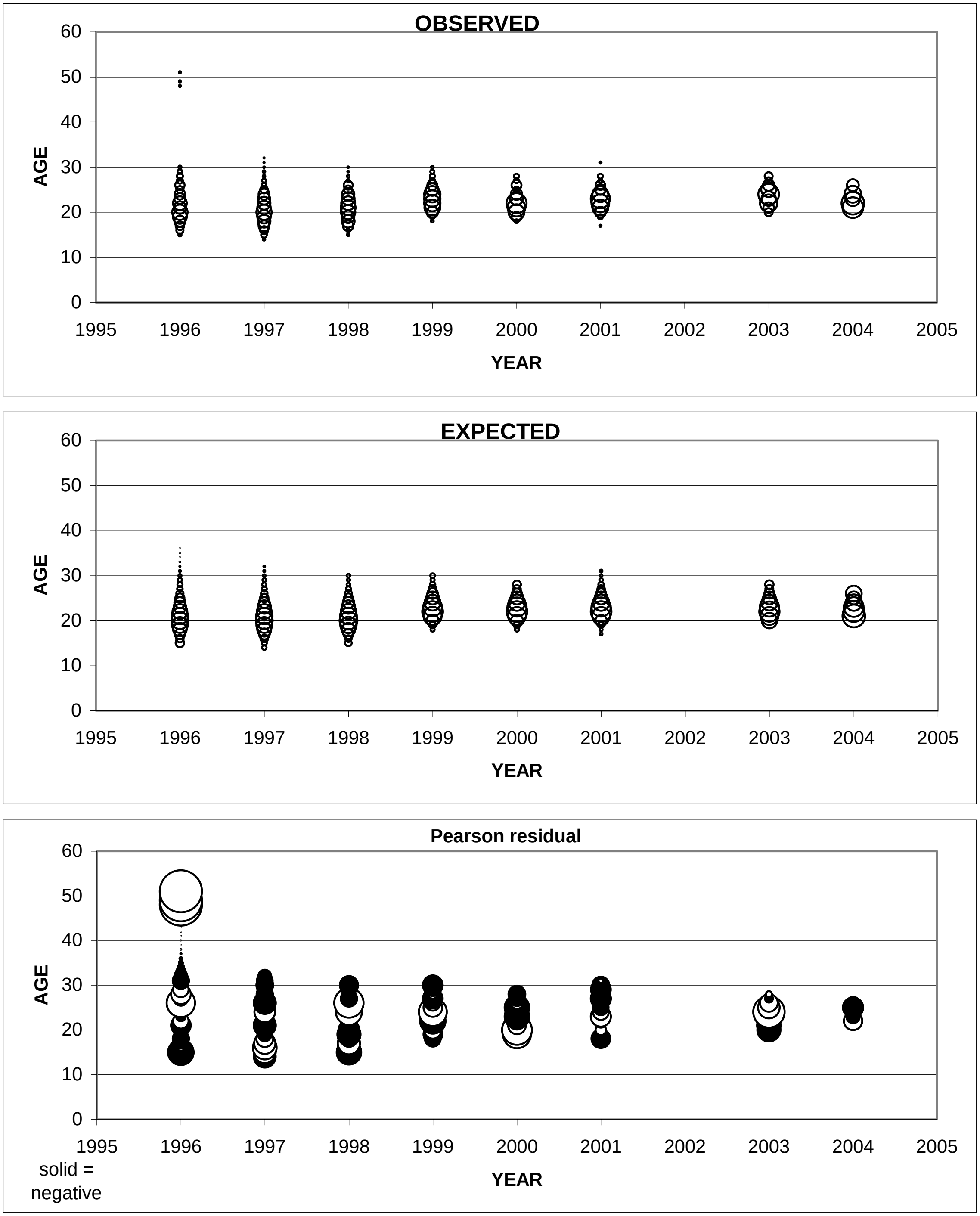


Figure D5.2c. Fit to the trawl commercial length frequency data.

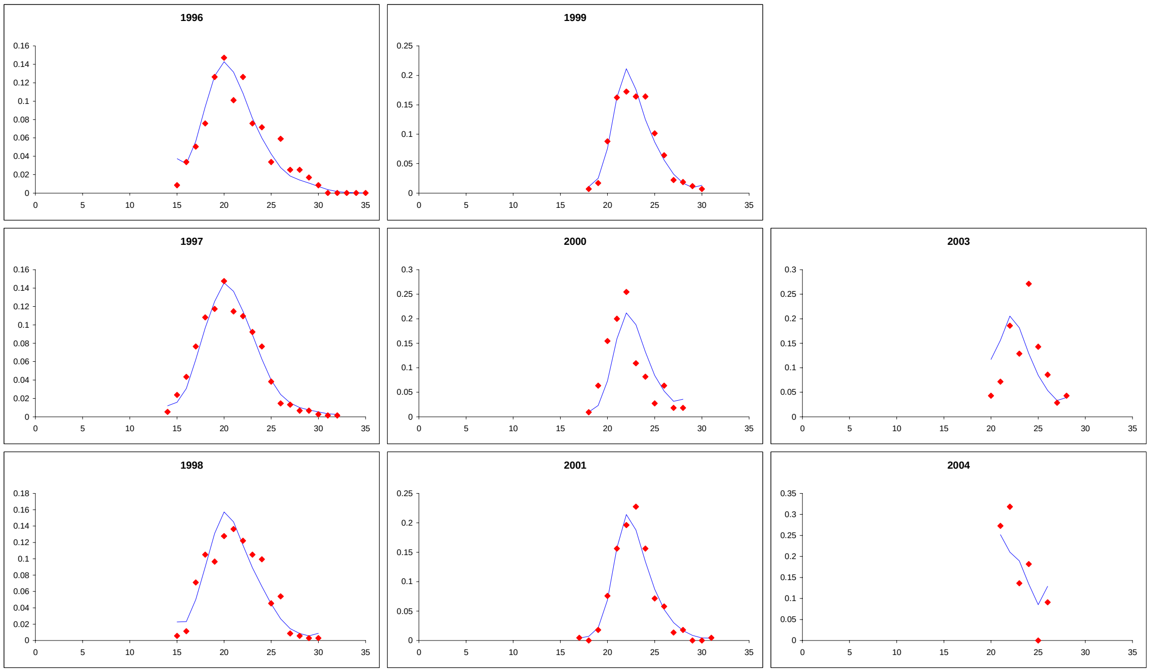


Figure D5.2c continued. Fit to the trawl commercial length frequency data.

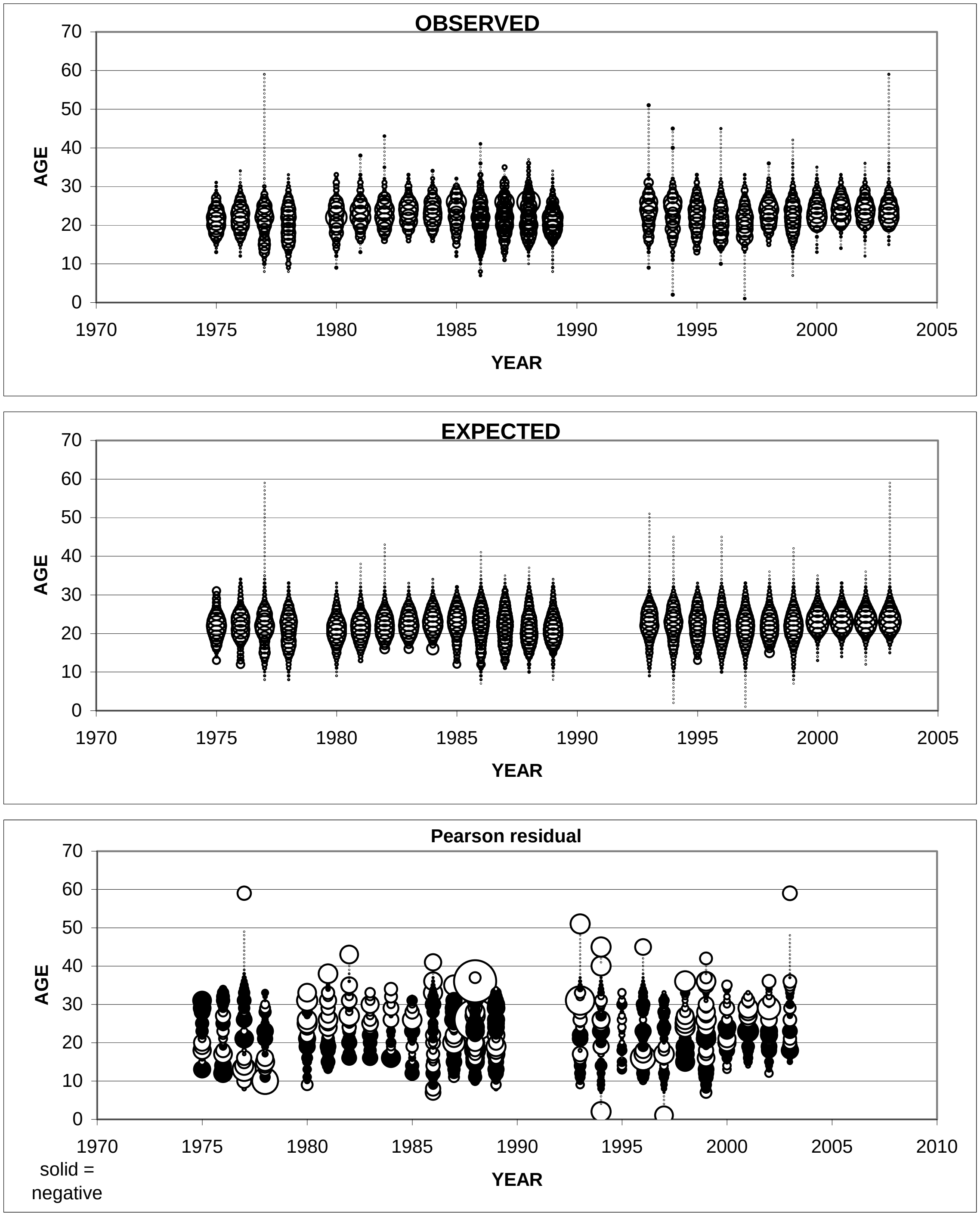


Figure D5.2d. Fit to the recreational length frequency data.

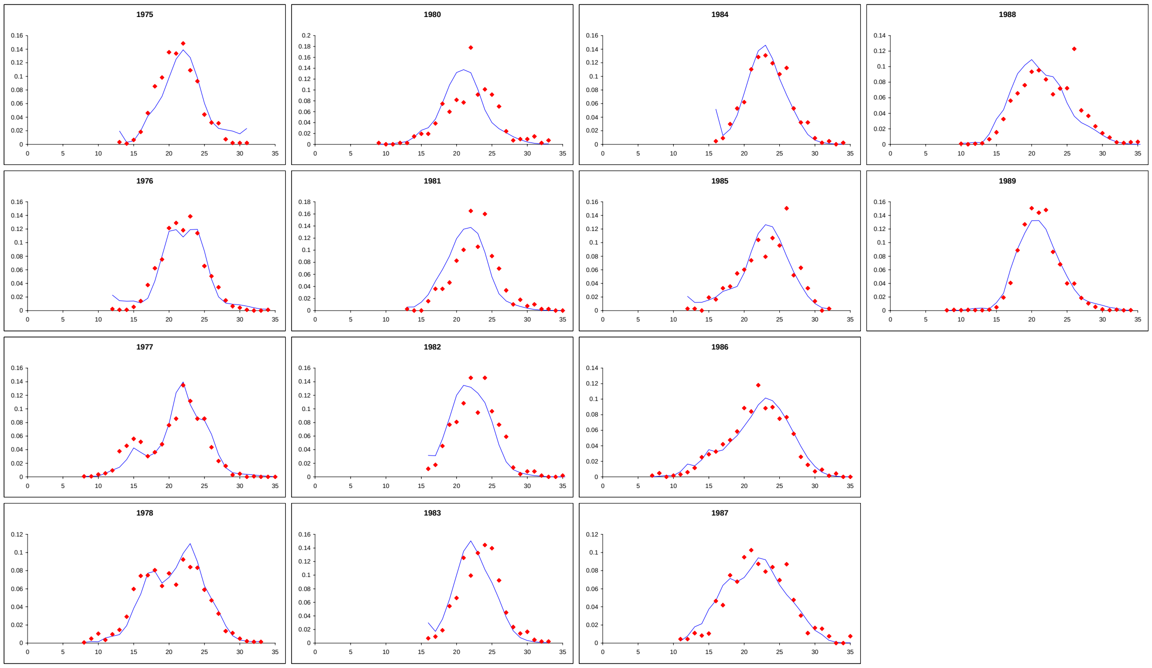


Figure D5.2d continued. Fit to the recreational length frequency data.

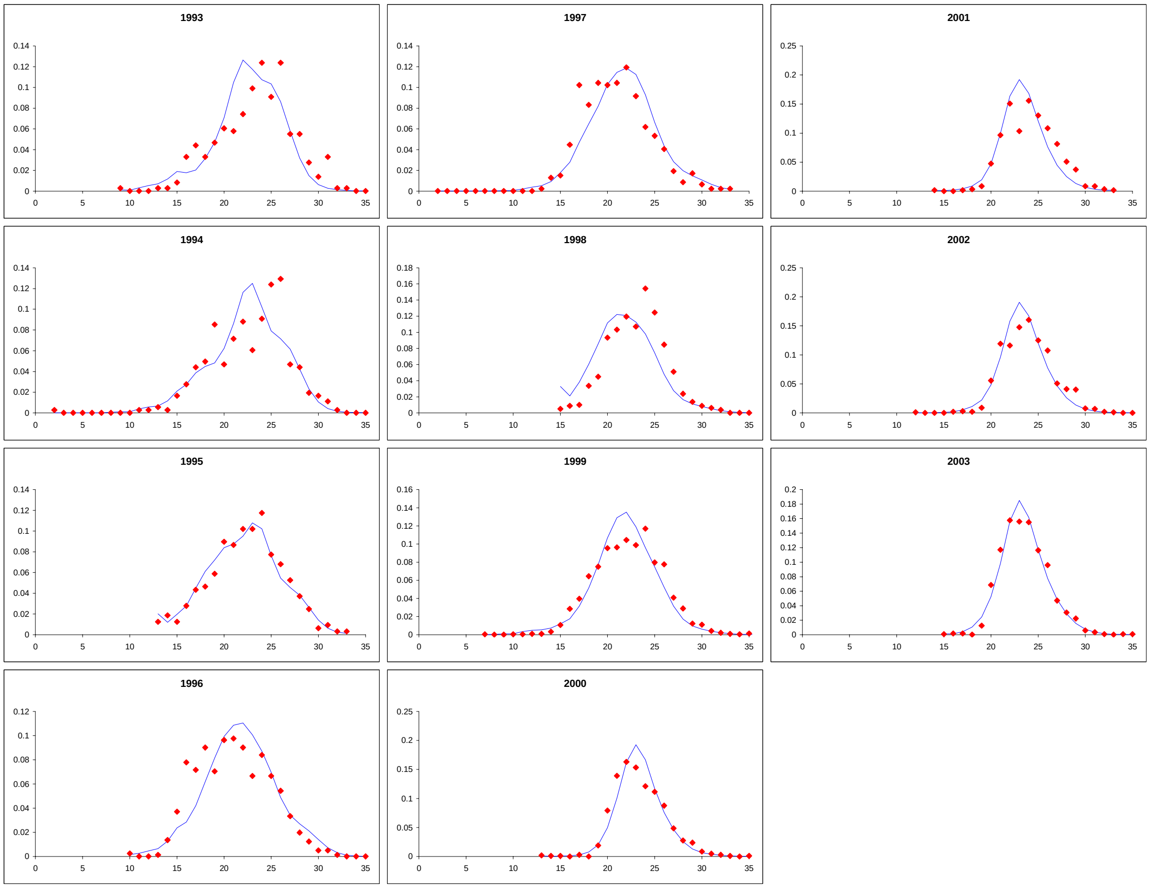


Figure D5.2d continued. Fit to the recreational length frequency data.

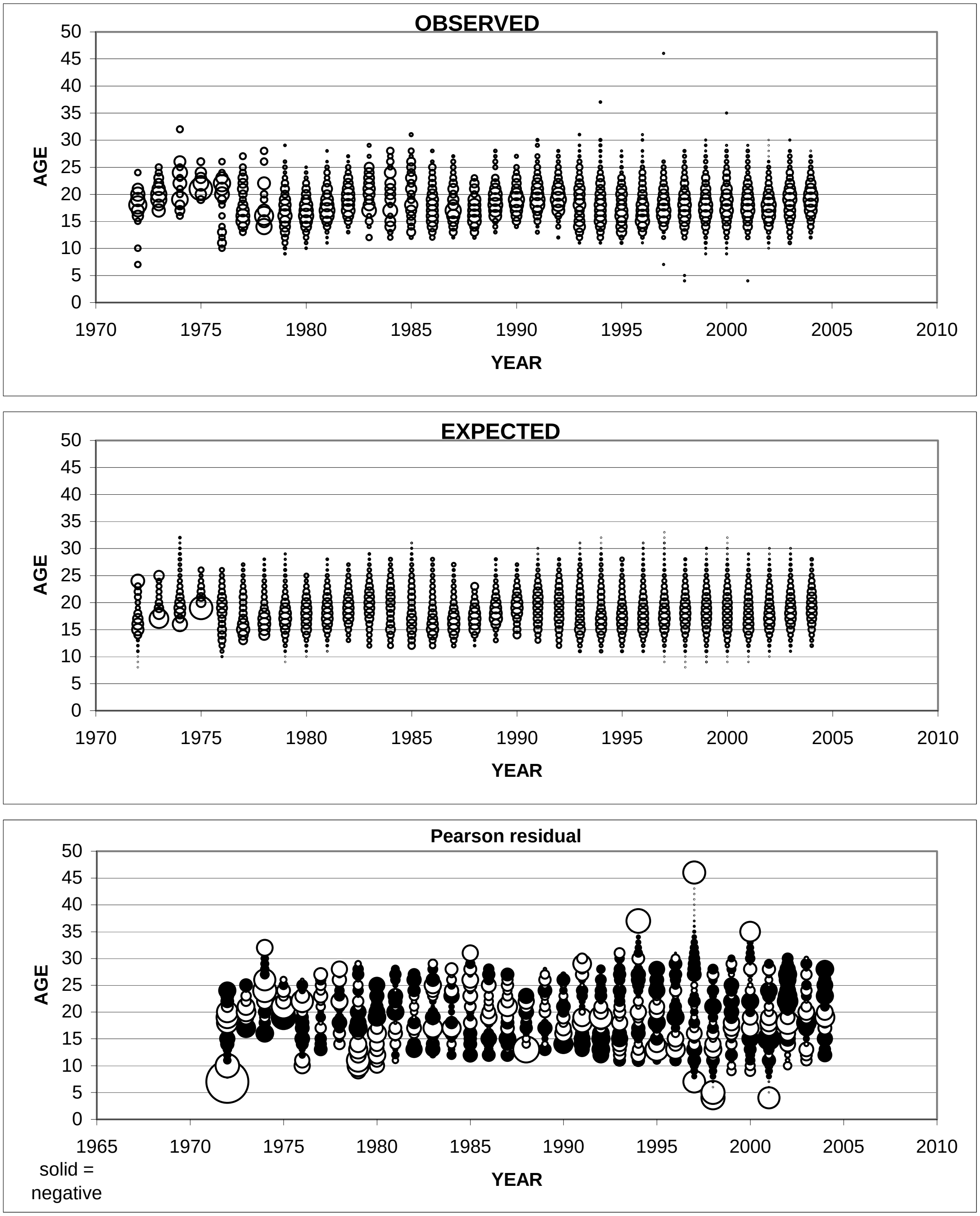


Figure D5.2e. Fit to the sanitation survey length frequency.

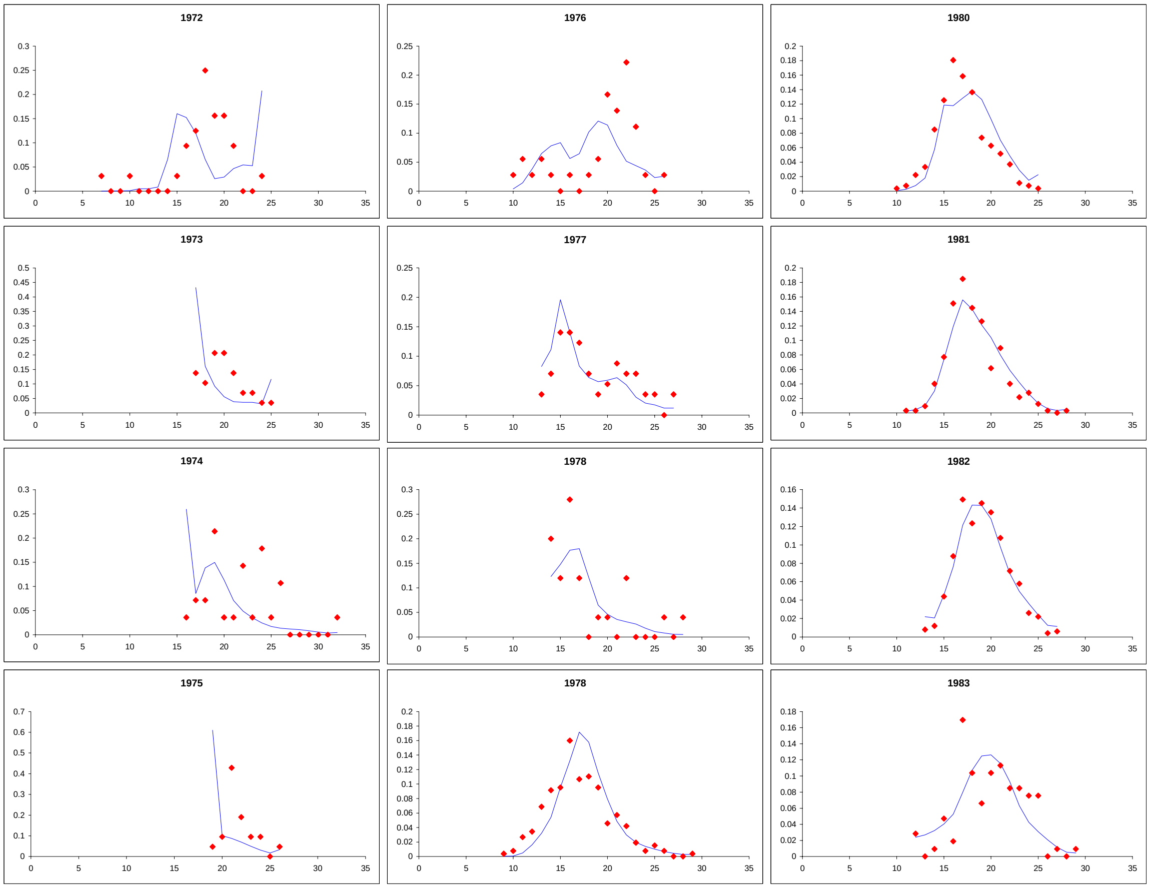


Figure D5.2e continued. Fit to the sanitation survey length frequency.

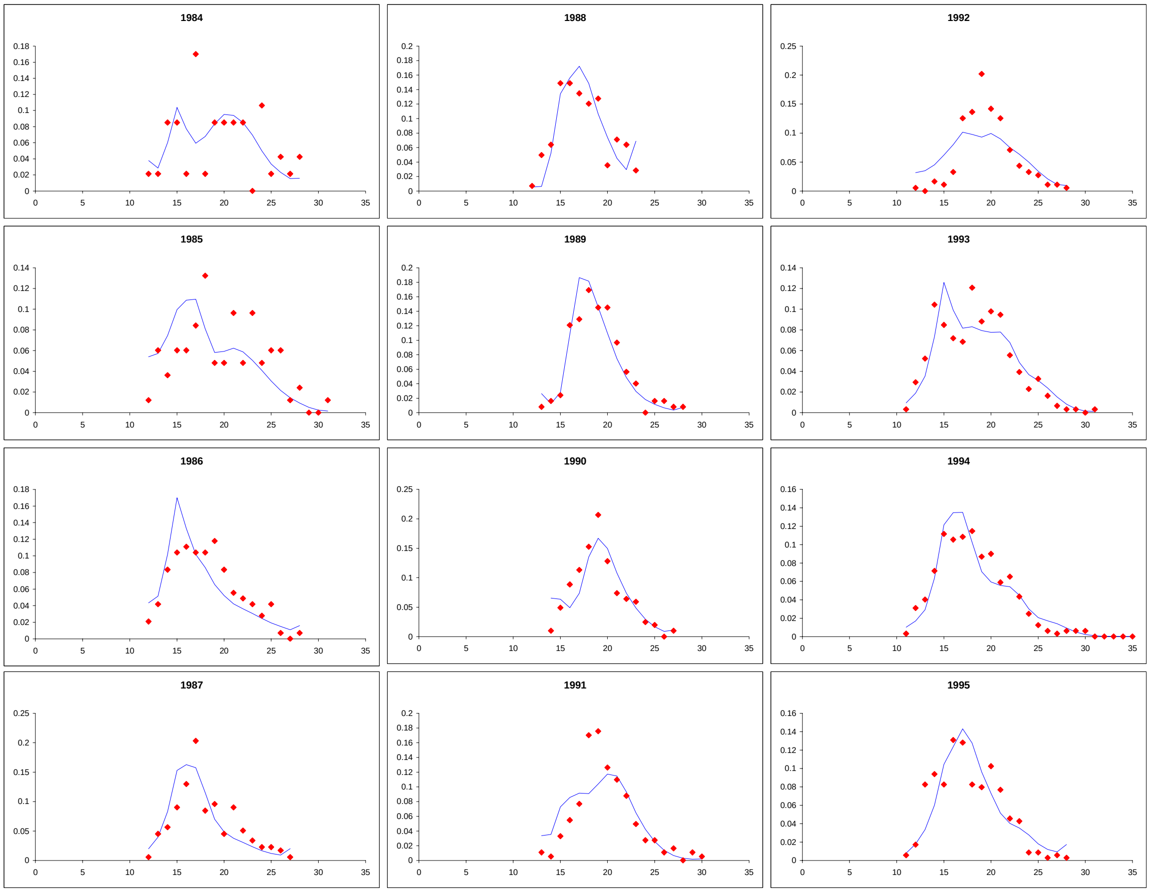


Figure D5.2e continued. Fit to the sanitation survey length frequency.

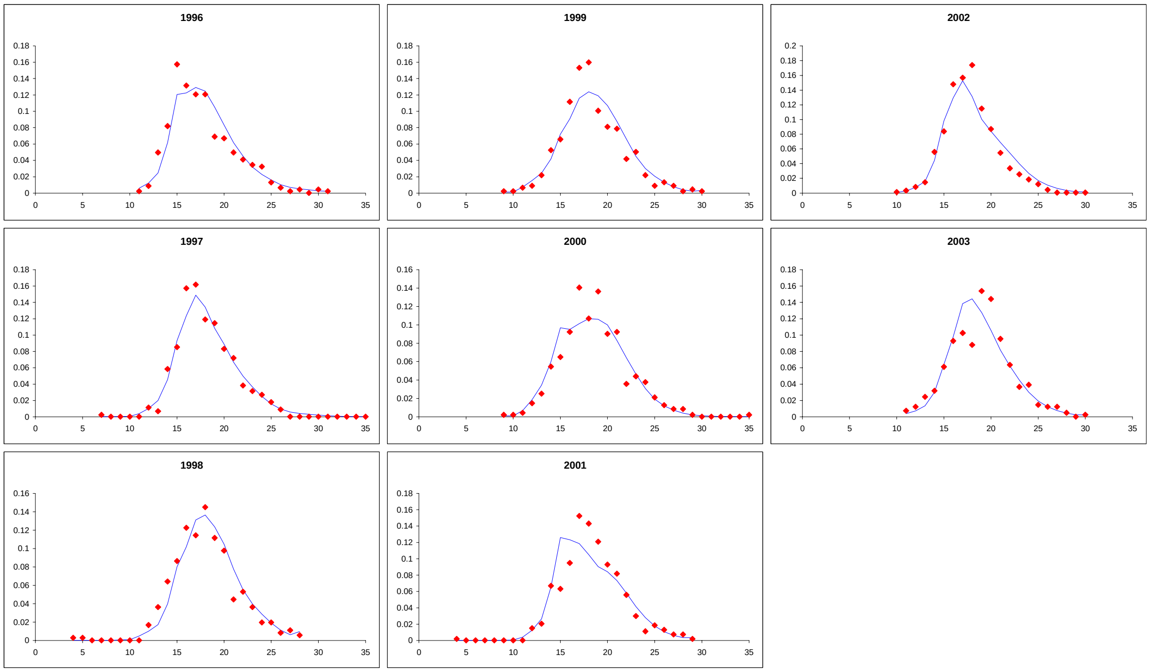
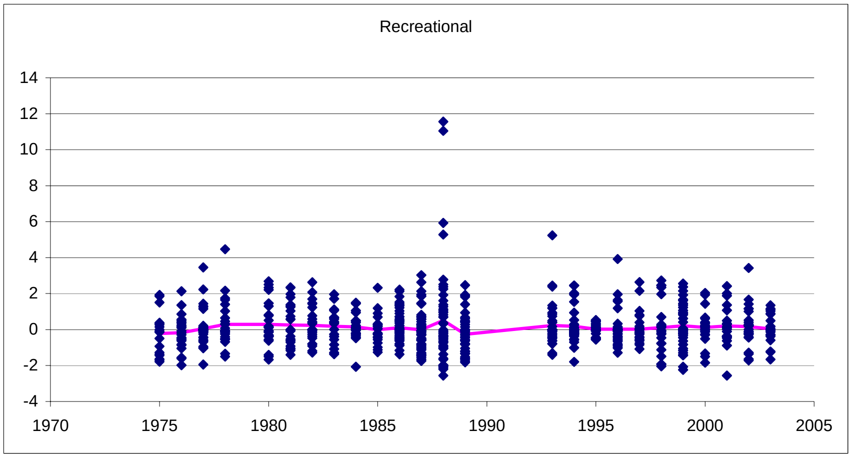
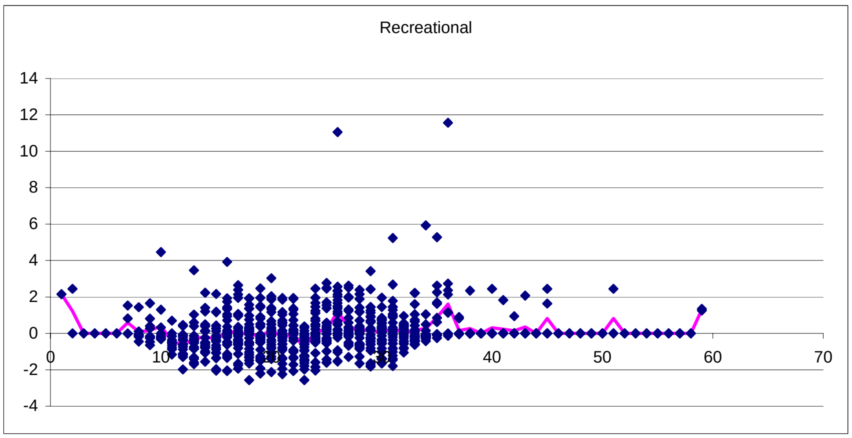


Figure D5.2e continued. Fit to the sanitation survey length frequency.





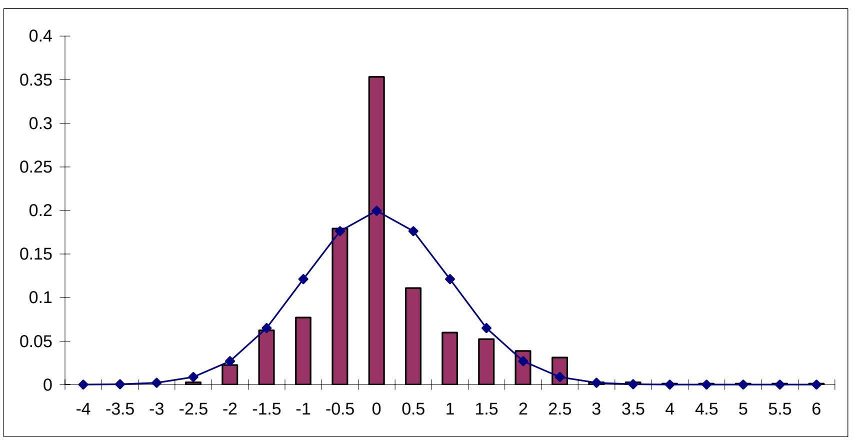
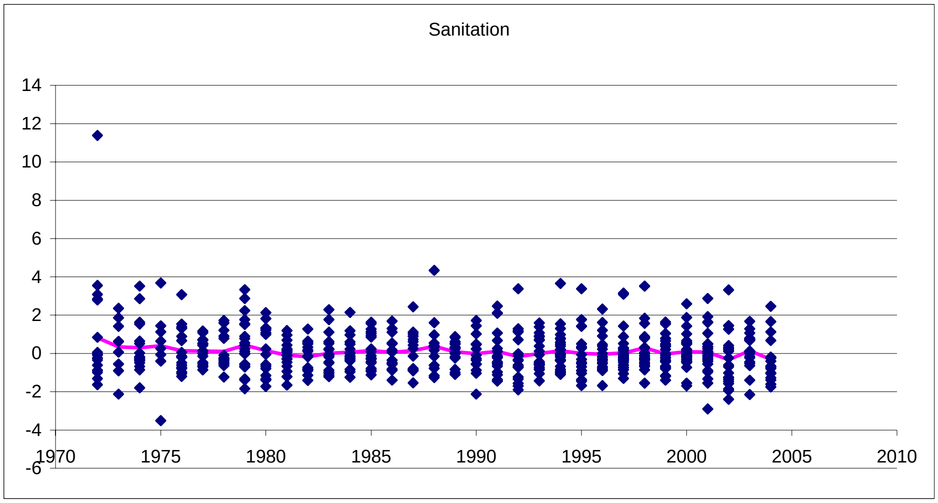
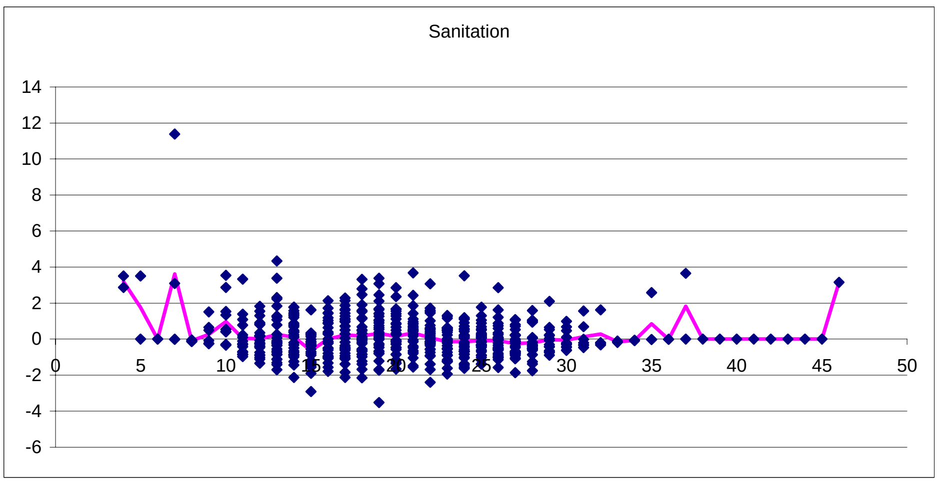


Figure D5.2f. Standardized residuals from the fit to the recreational length frequency. Top – by year, Middle – by length. The large numbers of zeros is due to the method of choosing the length-frequency bins to use in the likelihood. This method includes many bins with zero observed individuals, which are also predicted to have zero individuals.





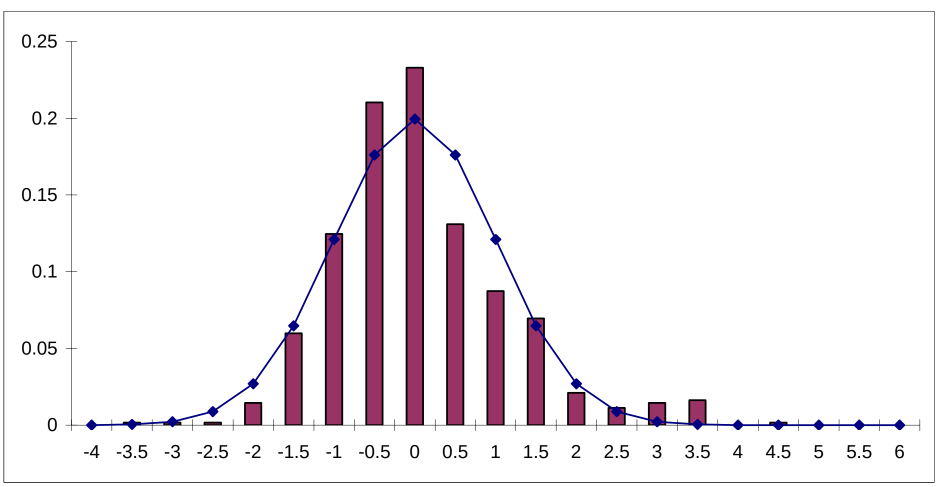


Figure D5.2g. Standardized residuals from the fit to the sanitation survey length frequency. Top – by year, Middle – by length.

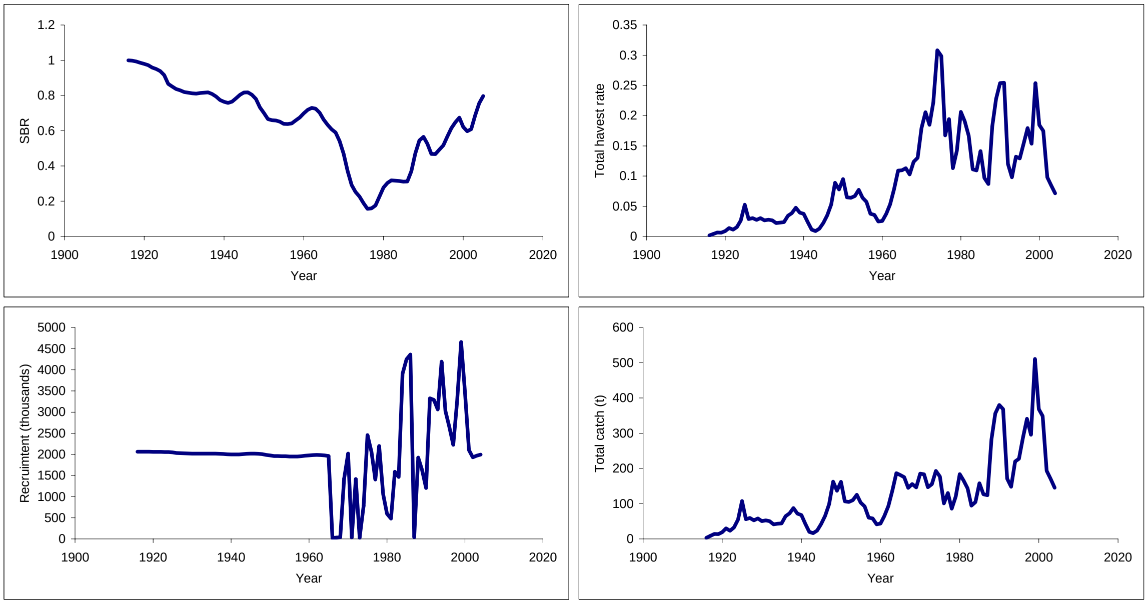


Figure D5.3. Spawning biomass ratio, exploitation rate, recruitment, and total catch estimated for by the model.

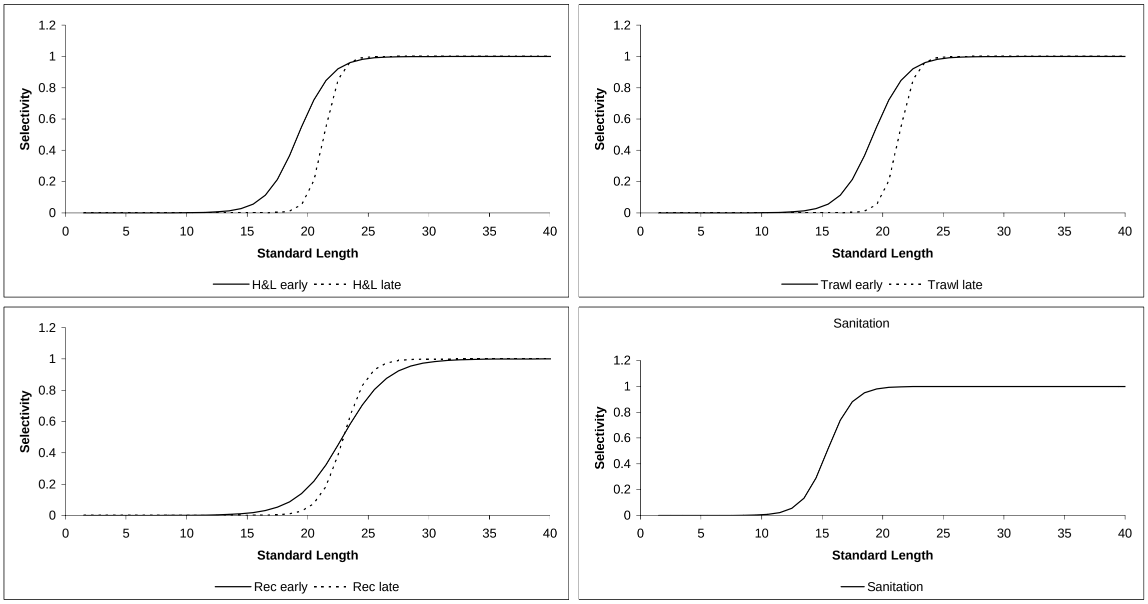


Figure D5.4. Estimated size specific selectivity curves for fisheries and sanitation survey.

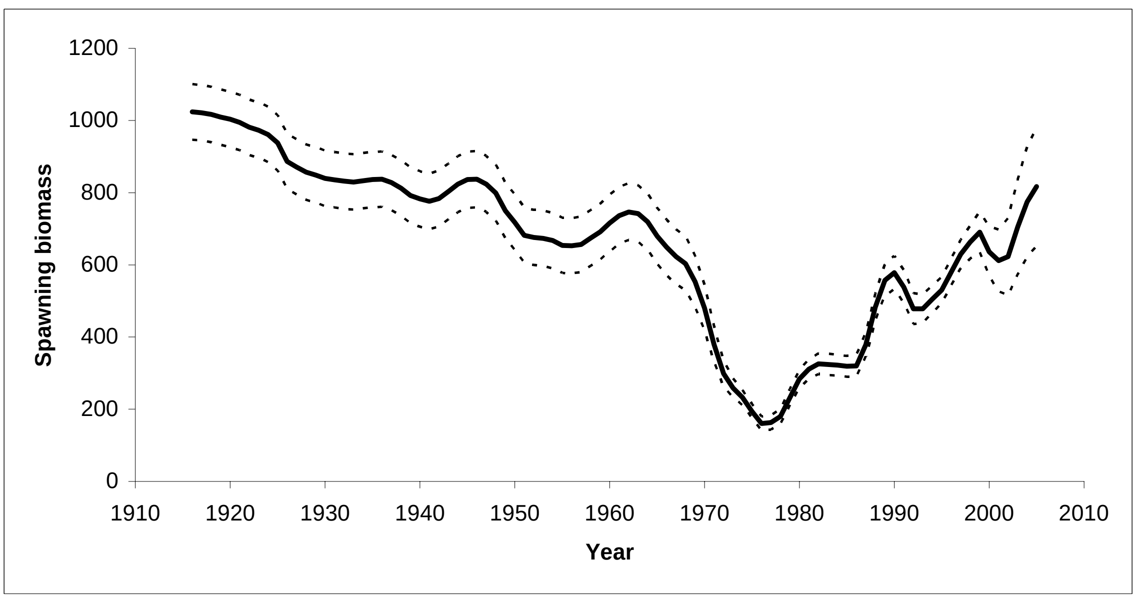
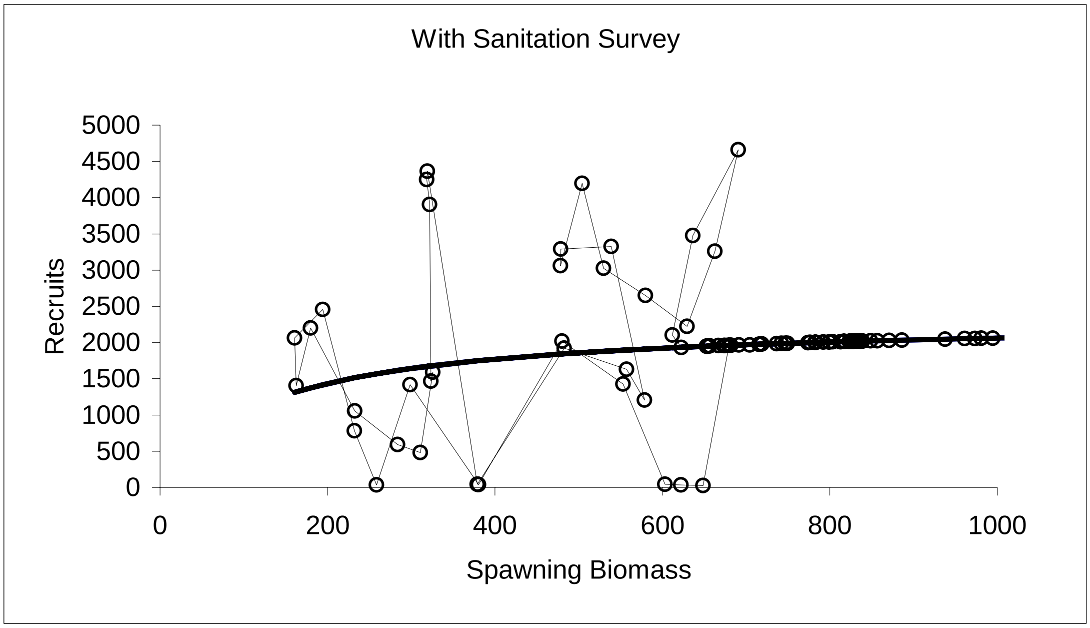


Figure D5.5. Spawning biomass and approximate 95% confidence intervals.



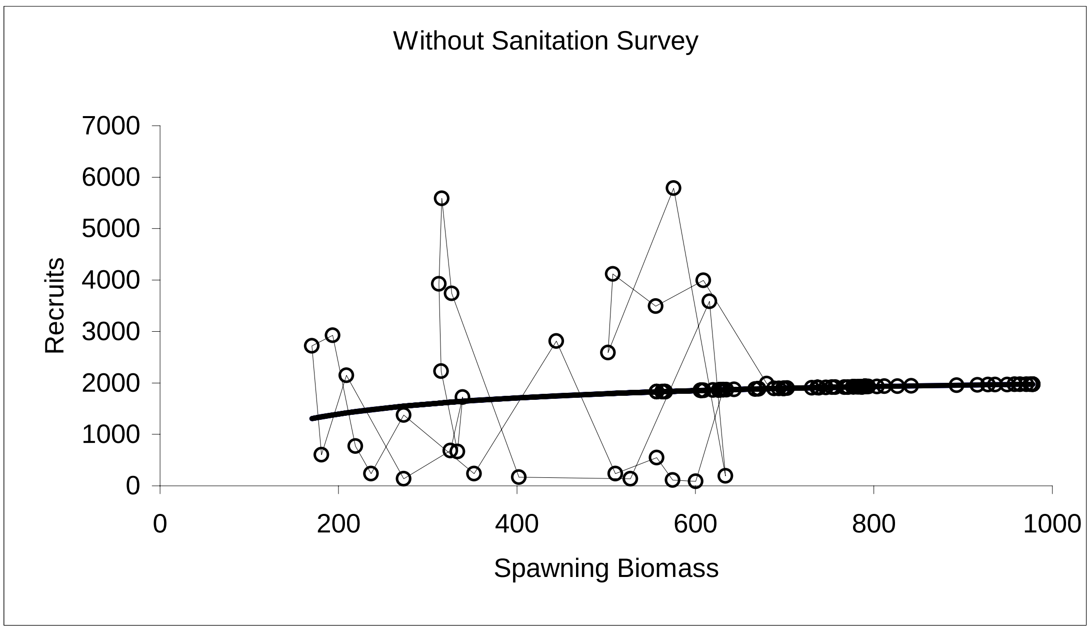


Figure D5.6 Spawner-recruit plots for the basecase and the sensitivity that excludes the sanitation survey.

6. Uncertainty and sensitivity analyses

The current status is sensitive to the inclusion of the sanitation index in the stock assessment; removing the sanitation index reduces the current biomass level. To match information content in the data, annual recruitment deviates were not estimated after 1996 when the sanitation district trawl survey was excluded from the analysis. The STAR Panel and STAT Team gave relative probabilities to models including and excluding the sanitation index of 74% and 26%, respectively. The results of the sensitivity analysis are shown in Figure D6.1.

Other sensitivity analyses were carried out to investigate natural mortality (M) steepness of the Beverton-Holt stock-recruitment relationship (h) and the coefficient of variation of the length-at-age (Lcv). The overall management implications of the results were not very sensitive to the values investigated (Table D6.1). The data supported higher values of all three parameters. When Lcv was estimated, it became unrealistically high and the exploitation rates become higher than 1, which is not plausible. This is the basis for *a priori* choosing a reasonable value for Lcv.

The model results were slightly (a few percent) sensitive to the initial parameter starting values due to local minima, including 2005 and 2006 catch based on the 2004 catch in the estimation period, and including the forward projections in the estimation model. However, this does not change the conclusions of the analysis.

There is a large amount of variation in recruitment levels and recent recruitments are estimated to be substantially higher than average. Predictions of future biomass will be dependent on what recruitment level is assumed in the future. Projections presented in this report use average recruitment based on the Beverton-Holt stock-recruitment relationship.

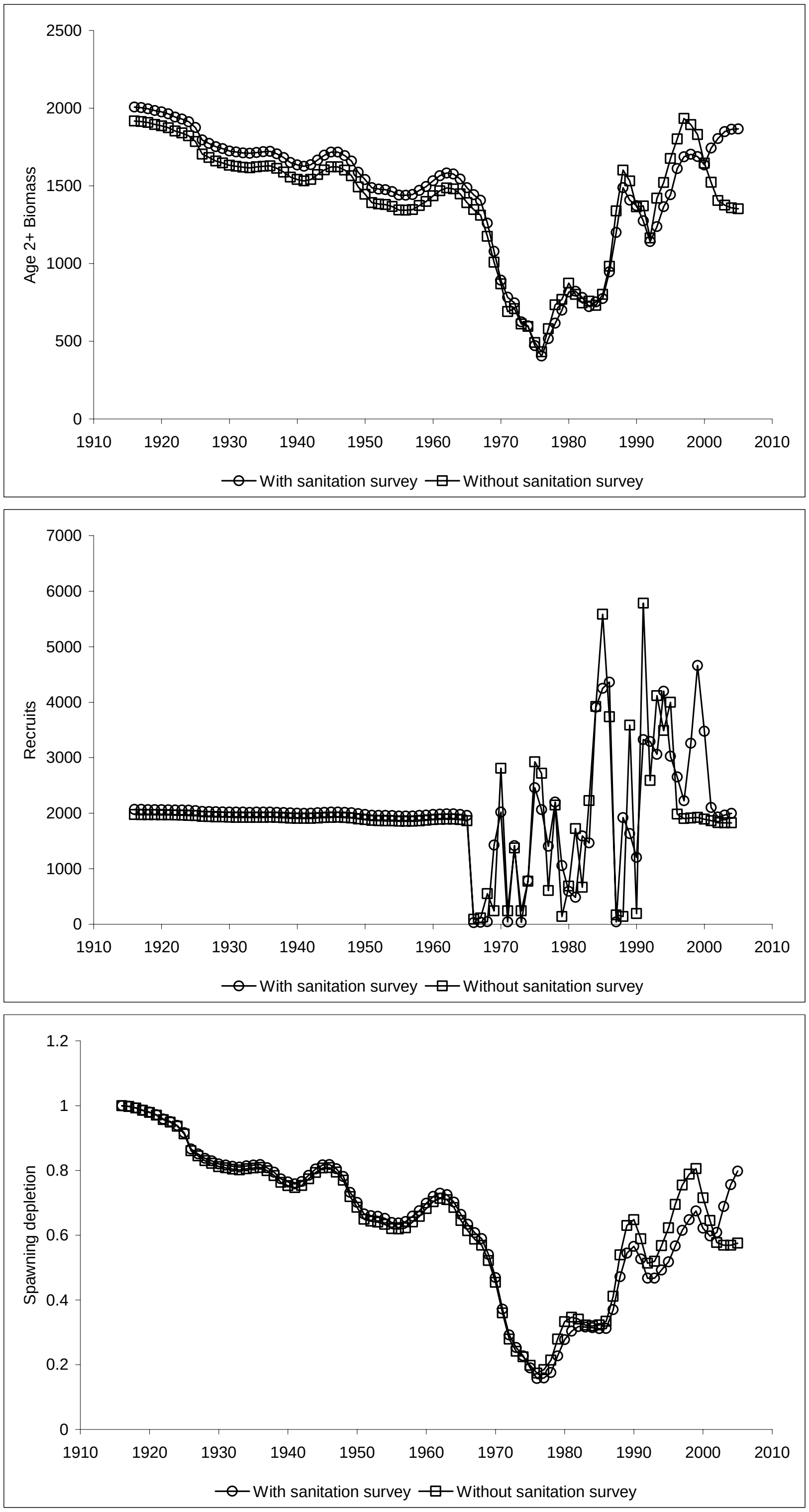


Figure D6.1. Comparison of age 2+ biomass, recruitment and depletion level from the sensitivity analysis excluding the sanitation survey and the base model that includes the sanitation survey.

Table D6.1. Results from the sensitivity analyses. Lcv is the coefficient of variation for the length-at-age.

	basecase	No sanitation	M = 0.2	M = 0.3	h = 0.5	h = 1.0	Lcv = 0.0.25	Lcv = 0.075	Lcv = 0.1
Unfished recruitment (R0; age 0)	2067	1975	1175	3339	2035	1944	2262	1841	1712
Unfished spawning biomass (SB0)	1024	978	973	1056	1008	963	1112	922	872
Depletion 2005	0.80	0.58	0.75	0.87	0.79	0.86	0.74	0.75	0.63
-LN(Likelihood)	836	NA	862	819	853	820	1014	761	723

E. Rebuilding parameters

The status of the stock does not require rebuilding.

F. Reference points (biomass and exploitation rate)

Table F1. Reference points estimated from the basecase analysis and the sensitivity excluding the sanitation survey index.

Biological Reference Points

Quantity	Include sanitation index	Exclude sanitation index
Unfished spawning biomass (SB_0)	1024	978
Unfished summary (age 2+) biomass (B_0)	2007	1918
Unfished recruitment (R_0; age 0)	2067	1975
$SB_{40\%}$ (MSY proxy stock size = 0.4xSB_0)	409	391
Exploitation rate at $F_{50\%}$ proxy	0.098	0.098
SB_{MSY}/SB_0	0.253	0.257
MSY	127	121
Exploitation rate at MSY	0.161	0.160